# ANATOMY OF THE RADIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH ITS CLINICAL APPLICATIONS.

***Dissertation submitted for***

**M.S. ANATOMY BRANCH – V**

**DEGREE EXAMINATION**


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# CERTIFICATE

This is to certify that the dissertation on **"RADIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH ITS CLINICAL APPLICATIONS"** is the bonafide work done by **Dr. M.JEYANTHI,** in the Institute of Anatomy, Madras Medical College, Chennai – 600 003, during 2005 – 2008 under my supervision and guidance in partial fulfillment of the regulation laid down by Tamilnadu Dr. M.G.R. Medical University, for the M.S. Anatomy Branch V examination to be held in March 2008.

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# CONTENTS

# *Introduction*

# INTRODUCTION

## ANATOMY – ITS IMPORTANCE

***"The body is an instrument, the mind its function, the witness and reward of its operation"***

**-George Santayana.**

**Andreus Vesalius**, father of modern anatomy, wrote in 1543 in the preface to his De Humane Corporis Fabrica, "Anatomy should rightly be regarded as the firm foundation of the whole art of Medicine and its essential preliminary".

Hence anatomy forms the first foundation stone of the medical career. Knowing anatomy is one thing and knowing it in detail is quite another. With anatomical knowledge the sails have already been put to hoist but with the details in it, the winds have started blowing. The resultant effect is that the ship is on the move. Also with detailed knowledge in anatomy precision teaches its zenith with a happy out come for the concerned and the considerate.

By the way, even in appreciating the deep realms of pathology, anatomy stands as a fathom stick. The systemic arteries all stem from the aorta and by branching and re-branching from what is some times spoken of as the 'arterial tree'. Its ultimate branches or arterioles lead into the capillaries by which the tissues of the body are supplied with blood.

The situation of the larger arteries in the trunk and limbs affords them natural protection from injury. Thus, the main artery of each limb passes from the trunk into the medial side of the limb and runs directly on the flexor aspect; accordingly as the limb is bent, the vessel is increasingly safeguarded. Further, its position on the flexor aspect lessens the tension exerted upon it during movements of the limb joints.

Around the limb joints there are notable anastomoses between medium sized arteries; those anastomoses are of clinical importance as they are the means by which the blood supply to the distal part of the limb is maintained by the opening up of a collateral circulation should the main artery be blocked by ligature or disease. Quiring (1949) provides as convenient, illustrated survey of the chief anastomoses both arterial and venous, in the body.

The radial artery is smaller than the ulnar artery, yet appears a more direct continuation of the brachial artery. It normally starts 1cm distal to the flexion crease of the elbow (fig 1). It descends along the lateral side of the forearm, accompanied by paired venae comitantes, from the medial side of the neck of the radius to the wrist, where it is palpable between flexor carpi radialis medially and the salient anterior border of the radius (fig – 2).

Proximally it is overlapped anteriorly by the belly of brachioradialis, but elsewhere in its course it is covered only by the skin, and superficial and deep fasciae. At the wrist the radial artery passes on to the dorsal aspect of the carpus between the lateral carpal ligament and the tendons of abductor pollicis longus and extensor pollicis brevis (fig – 3).

It crosses the scaphoid bone and trapezium (in the ‘anatomical snuff box’) and as it passes between the heads of the first dorsal interosseous muscle it is crossed by the tendons of extensor pollicis longus(fig – 5). Between the thumb extensors, it is crossed by the start of the cephalic vein and the digital branches of the radial nerve which supply the thumb and index finger.

In the hand the radial artery passes through the first interosseous space between the heads of the first dorsal interosseous and crosses the palm. At first it lies deep to the oblique head of adductor pollicis and then passes between its oblique and transverse heads or through transverse head. At the fifth metacarpal bone it anastomoses with the deep branch of the ulnar artery, completing the deep palmar arch (fig – 4a).

Branches in the forearm are, radial recurrent artery, cutaneous branches, muscular branches.

Branches in the wrist and palm are palmar carpal branch, superficial palmar branch, dorsal carpal branch, first dorsal metacarpal artery, arteria princeps pollicis, arteria radialis indicis and the terminal part which forms the deep palmar arch by joining with the deep branch of the ulnar artery.

# *Aim of the Study*

# AIM OF THE STUDY

Variations and abnormalities of the vascular system are the special interest to the anatomist because of their morphological significance. The vascular system is rich in such variation, many of which are of great practical importance.

With the exception of those directly due to the effect of morbid conditions and external influence, all variations are the result of modifications of normal developmental processes. The exception referred to are, however, very numerous; thus disease or injury may lead to the obliteration of vessels – a condition which is invariably associated with the enlargement of collateral vessels. Variations which are determined by or are dependant upon modifications of the usual developmental processes are of greater interest.

Anomalies of the forelimb arterial tree are fairly common, probably because they have multiple and plexiform sources. In general anomalous pattern may present as differences in mode and proximodistal level of branching, the presence of unusual compound arterial segments, aberrant vessels, arcades, plexuses.

The radial artery is superficial in the distal forearm and lies on the lateral side of flexor carpi radialis tendon. It's pulsation can readily be felt, supplying information of clinical importance, such as rate, rhythm, compressibility and condition of arterial wall. The arterial variations of the upper limb have been implicated in different clinical situations. The brachioradial and superficial

brachio ulnar arteries have been encountered during elevation of the radial forearm flap.

Possible intra arterial injection of drugs due to the proximity of normal vein puncture sites has also been reported as well as possible arteriographic misinterpretations when the contrast dye is injected distal to the origin of these variant arteries. The existence of a superficial radial artery implies the absence of the normal radial pulse at wrist level and also it produces problems in cannulation for operation monitoring.

The absence of the ulnar artery was responsible for hand ischaemia after radial artery conduit for coronary bypass. So preoperative assessment of the radial artery and collateral hand circulation is mandatory to avoid hand ischaemia in patients with inadequate collateral circulation.

Radial artery is the commonest one affected in some vascular diseases, crush injuries which will lead to ischaemia of the hand where the role of vascular surgeons is very essential to manage. Radial artery is the foremost one used for arterio-venous fistula by nephrologists in chronic renal failure and by diabetologists for dialysis purpose.

Because of its histological similarity with coronary artery, it is being used by cardiothoracic surgeons for coronary revascularization which results in long term patency, improves long term outcome, leads to low morbidity, and good functional outcome of the hand after harvesting the radial artery (fig–6, 7).

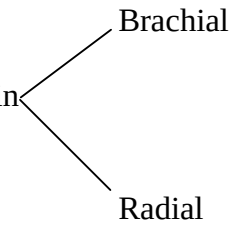
The feasibility of performing coronary angiography or percutaneous coronary intervention through radial artery has been broadly evaluated and major advantages of this approach compared to classic femoral one, mainly include reduction of local vascular complications and patient's short ambulation.

Extensive studies have been done by many scientific experts regarding variation pattern of radial artery and also by many cardiothoracic surgeons regarding its merits and demerits in coronary artery bypass grafting. (CABG)

Even though the branches of radial artery are very few, the variations are not uncommon. So the knowledge about the radial artery, its branches and its variations are very much important for the vascular surgeons, nephrologists, plastic surgeons and cardio – thoracic surgeons; according to which they can modify the surgical procedures in a most satisfactory way.

So the present study of radial artery was undertaken by me to study the course, branching pattern, its variation and also the histological similarity with coronary artery. The radial artery is studied under the following parameters.

1. Origin of the radial artery
2. Course of the radial artery
3. Branches

a) Radial recurrent branch – Origin 

b) Superficial palmar branch – its origin and its contribution to the completion of the Superficial Palmar Arch.

c) Arteria princeps pollicis origin
- dorsal side
- palmar side

d) Arteria radialis indicis origin
- dorsal side
- palmar side

e) Palmar carpal branch

f) First dorsal metacarpal artery

g) Dorsal carpal branch

h) Origin of interosseous artery from the radial artery

4) Completion of superficial palmar arch

5) Formation of deep palmar arch.

# *Review of Literature*

# REVIEW OF LITERATURE

**Quains (1844)** was believed to be the first person to provide sufficient data for better statistical evaluation regarding radial artery. In his series of dissection with 481 extremities he encountered 19.5% of anomalies of radial artery affecting its origin or course.

**Henry Gray (1858)** described, though smaller than the ulnar, the radial artery appears of more direct continuation of the brachial artery and it begins about 1cm distal to the bend of elbow (at the level of neck of radius) and traverses up to its styloid process in the distal part. Then the radial artery descends along the lateral side of the forearm to wrist and then curls posterolaterally round the carpus, beneath tendons of abductor pollicis longus, extensor pollicis brevis and extensor pollicis longus to the proximal end of the first inter metacarpal space, swerving medially between heads of the first dorsal interosseous into the palm and then crossing medially to form the deep palmar arch with the deep branch of the ulnar artery. Proximally it is overlapped by the belly of brachioradialis, rest is covered by skin, superficial and deep fasciae. Sometimes the radial artery arises proximally, usually from the axillary artery. He mentioned that the arteria princeps pollicis is the usual nutrient artery supply to the first metacarpal bone. The Superficial palmar branch arises from the radial artery just before it curves round the carpus, passes through and occasionally over the thenar muscles, which it supplies, sometimes anastomoses with the end of ulnar artery to complete the superficial palmar arch.

Anterior carpal branch, posterior carpal branch and the first dorsal metacarpal branch are the slender branches arising from the radial artery anterior and dorsal part of the wrist. The arteria princeps pollicis et radialis indicis may be continued as the first palmar metacarpal artery. They may arise from the superficial palmar arch. The deep palmar arch is formed by anastomosis of the end of the radial artery with the deep branch of the ulnar artery. The radial artery can give rise to the common interosseous artery.

**Poirier (1886),** In his text book of anatomy, "superficial brachial artery" is discussed. In 100 dissections the brachial artery crossed superficial to the median nerve 6 times "High origin" of the radial artery according to Poirier, is rarer.

**Charles (1894)** recorded a case of absence of the radial artery, its place at the wrist was taken by the anterior interosseous artery which wound around the radial border of the wrist deep to the long tendons of the thumb and entered the palm of the hand by passing between the first and second metacarpal bones in the fashion of a normal radial artery.

**Prof. Johnston (1921)** in his synopsis of "Regional Anatomy" described that , the radial artery is comparatively superficial throughout its whole course, but particularly in its lower half. It arises from the brachial artery in cubital fossa and runs forwards, curving laterally to the wrist. The radial artery is overlapped by the brachioradialis, but in the lower half of its extend it is covered only by the skin, the superficial and deep fasciae. The superficial palmar branch of radial artery frequently completes the superficial palmar arch. The deep palmar

arch represents the direct continuation of the radial artery into the palm, the arch being completed on the medial side by union with the deep branch of the ulnar artery.

**Dubreuil Chambardel (1926)** mentioned that the median artery contributed to the formation of superficial palmar arch seen in 4% of 1200 cases.

**Beuntaro Adachi (1928)** a Jaspanese anatomist described 3 types of superficial palmar arch.

a) The “ulnar type” in which the contribution by the radial artery is absent or minimal.
b) The “radio-ulnar” type
c) The “medio-ulnar” type in which a median artery is sufficiently strong to reach the palm of the hand and to take part in the formation of arch.

According to him the ulnar type is the more frequent (59%), next the radio-ulnar (32%) and the medio-ulnar type the least common (9%).

Adachi also describes a rare abnormality which was seen 8 times in 698 dissection (1.1%). It may be called superficial radial artery, which is given off at varying level in the forearm. It is thicker than the continuing trunk, travels dorsally across the surfaces of the brachioradialis muscle and runs downwards in the superficial fascia. Over the thumb tendons and ends like the normal radial artery by piercing the first interosseous space.

The continuing smaller trunk of the radial artery takes a normal course to the wrist then deep in the thumb tendons and usually ends in the posterior carpal arch.

**Degaris and Swartley (1928)** recognized 23 different patterns of axillary artery and its branches in their study based on 512 dissection and found 7.7% of high origin of the radial artery. Among these 2.7% are of white 5% of negro arms.

**George A.Piersol (1930)** described that the radial artery is the smaller of two terminal branches of brachial artery and arises at the bend of the elbow and passes down the lateral border of the forearm to the level of the styloid process of radius where it bends laterally and extends downwards over the dorsum until it reaches the interval between the first and second metacarpal bones and again changes its direction and passes forwards into the palmar surface of the hand, across which it is continued medially over the anterior surface of the second, third and fourth metacarpals forming deep volar arch. It terminates opposite the proximal part of the fourth metacarpal interspace by anastomosing with deep volar branch of the ulnar artery.

The volar radial carpal, the dorsal radial carpal and the first dorsal metacarpal arteries are very slender branches and make anastomosis with branches from volar ulnar carpal, dorsal ulnar carpal and the first dorsal metacarpal artery passes distally along the radial border of the second metacarpal and terminates upon the first phalanx of the index finger.

The superficial volar branch occasionally arises high upon the radial and frequently it takes no part in the formation of the superficial volar arch and may terminate in the muscles of the thenar eminence, the digital branches being given off by the superficial volar branch of the ulnar artery. The arteria

princeps pollicis arises from the radial just as it emerges from between the two heads of dorsal first interosseous muscle. He also stated that the arteria princeps pollicis and the arteria dorsalis indicis may be well developed and arise directly from the deep volar arch.

**Thomas Walmsley (1934)** has described the radial artery as the smaller of the division of brachial artery though it appears to be the more direct continuation of brachial artery. Upper part of radial artery is undercover of medial part of fleshy belly of brachioradialis and lower part is deep to deep and superficial fasciae and skin. He also says that sometimes the radial artery lies superficial to the deep fascia, instead of beneath it, in its whole course and sometimes it arises from the axillary artery or the upper part of the brachial artery.

The superficial palmar artery, arise near the root of the thumb and runs distally first superficial to and then among its short muscles. It often completes the superficial palmar arch.

Radial artery enters palm from dorsum of hand by passing through first interosseous space and in the palm, it lies undercover or amongst the fibres of the obliquous portion of the adductor pollicis and emerges between the border of this and the transverse part of muscle and then passes across the palm as deep palmar arch which is completed on the medial side by anastomosis with the deep branch of the ulnar artery. According to him, from the radial artery in the palm, there usually arises two branches. The arteria princeps pollicis, which however, sometimes arises on the back of the hand.

The second branch, arteria radialis indicis passes forwards to the radial side of index finger. It may give off a branch which completes the superficial palman arch. Anterior carpal branch, posterior carpal branch are slender branches arising from the radial artery anteriorly and dorsally. Slender dorsal metacarpal arteries arising from the posterior carpal arch.

**J.E. Frazer (1937)** has described that the radial artery is one of the two terminal branches of the brachial artery which in the cubital fossa opposit the upper part of the neck of the radius divides into radial and ulnar arteries. Radial artery is smaller than the ulnar, its direction is at first continuous with parent trunk. He subdivided the radial artery into 3 parts.

I part- Occupying forearm – from origin to the styloid process of the radius.

II part- the back of the wrist

III part- the palm.

The artery may arise from the upper part of the brachial or from the axillary – then it may descend superficially to the bicipital aponeurosis of the biceps and deep fascia of the forearm. It may end at the lower part of the forearm, its distribution being replaced by branches of the ulnar, median or anterior interosseous arteries. It gives radial recurrent branch close to its commencement.

The third part forms greater portion of the deep palmar arch, extends inwards from the proximal end of the first inter metacarpal space to join the deep branch of the ulnar artery.

The princeps pollicis artery arises from the radial extremity of the deep arch. The radialis indicis artery passes downwards on the outside of the second metacarpal bone. The princeps pollicis and radialis indicis arteries not infrequently arises by a common trunk or may be derived from the superficial arch, from an enlarged median artery or from the superficial palmar branch. Superficial palmar arch is completed by superficial palmar branch of the radial, or failing this by a branch from the radialis indicis artery or from the princeps pollicis artery. Anterior, posterior carpal branches are slender branches from the radial artery. The first dorsal meta carpal artery arises directly from the radial or from the posterior carpal branch.

**Miller R.A (1939)** found bilateral high origin of the radial artery in 15 of 480 bodies about 3 percent.

**C. Latimer Callander, Dean Lewis (1939)** have mentioned in their book, "Surgical Anatomy" that the radial artery arises at the level of the coronoid process of ulna and the neck of radius, continuous in direction of the brachial trunk. It runs a fairly straight course through the forearm. In the distal third, it is subcutaneous and lies on the radius and on the flexor pollicis longus muscle. It gives off two large branches in the forearm, the radial recurrent artery near its origin and the superficial volar artery in the distal part of the forearm. The superficial volar artery, runs through the short muscles of the thumb to meet the ulnar artery and complete the superficial palmar arch.

**J.Parsons Schaeffer (1942)** quoted that the radial artery is smaller of the two arteries and appears as a direct continuation of brachial artery. It runs along the

radial side of forearm as far as the styloid process and curving over the lateral side and back of the wrist, enters the palm between the bases of the first and second metacarpal bones and ends by anastomosing with deep branch of ulnar to form deep volar arch. The course is divisible into 3 parts – that in forearm, that at the wrist and that in the palm of the hand.

He described about radial recurrent artery ; which usually arises from the lateral side of the radial just beyond its origin from brachial.

The superficial volar branch courses forward over the short muscles of the ball of the thumb, and anastomoses with the superficial branch of the ulnar artery to complete the superficial volar arch. The volar radial carpal, dorsal radial carpal and the first dorsal metacarpal arteries are the other slender branches of the radial artery.

**Cohen S.M. (1948)** reviewed 12 cases of intra arterial injection of thiopental sodium of which six required forearm amputation. He concluded that spasm of the distal arterioles and late thrombosis of the arteries were the significant lesions.

**Barry J. Anson. (1950)** pointed out in his book – 'An Atlas of Human Anatomy' about the high division of brachial artery giving rise to smaller radial artery or a large radial artery.

**Emanuel B.Kaplan (1953)** has mentioned in his book "Functional and surgical anatomy of the hand" that the superficial arterial arch is formed by anastomosis with superficial branch of radial artery. He describes the variations of superficial palmar arch as follows.

1. The superficial palmar arch may have three variants.

The first variant, in which the ulnar artery is responsible for the formation of the superficial palmar arch, is encountered in about 66% of the cases.

2. The second variant of the superficial palmar arch in which the superficial radial palmar artery participate in the formation of the arch in encountered in about 30% of the cases.
3. The third variant of the superficial arch in which the median artery contributes to the formation of the arch. Very infrequently an additional subcutaneous branch of the superficial branch of the radial and a subcutaneous branch of the ulnar artery is found.

**Variations of the deep palmar arch**

The most frequent variation is the regular anastomosis between the radial artery and the deep branch of the ulnar artery. The anterior interosseous artery may participate in the formation of the deep palmar arch with the radial artery.

**Lawrence J. Mc Cormack, Cauldwell E.W. and Anson B.J. (1953)** observed the variation occurred in 139 of 750 extremities (18.53%) considered on the basis of the 364 (of 386) cadavers with both upper extremities represented, major arterial variations occurred in 112 (30.77%) Bilateral occurrence was recorded in 23 cadavers (6.32%) while the remaining 89 (24.45%) revealed variants unilaterally.

Mr.Cormack and his co-workers found a high origin of the radial artery to be far the most common variation of the arteries of the arm for it represented 77% of all the variations they observed, and was found in 14.27% of all specimens. In 2.13% of limbs the radial artery arose from the axillary artery, and in 12.41% from some part of the brachial artery.

In 6 specimens there occurred anomalous terminal distribution of the radial artery. In 5 of the 6 specimens, the radial artery divided in the distal fourth of the forearm into two large branches one of which continued along the medical border of brachio radialis muscle tendon and to enter the deep aspects of the palm. The second branch provided a strong contribution to the thumb and index finger and within the palm contributed the radial portion of the deep volar arch. In 80 of 750 specimen, they studied about superficial volar arch. In only 15 specimens was a volar arch is formed in the usual manner by a branch of the radial artery. In 41 cases a superficial volar arch was formed by a delicate arterial twig contributed to the ulnar artery.

**Weathersby (1954)** said that the superficial palmar arch is completed by the superficial palmar branch of the radial in about 35 percent of hands. In 12%, there was no connection of the arch to branches of the radial artery. On the radial side, sometimes it was with a branch of the princeps pollicis alone.

In 10% the first dorsal metacarpal artery passed between the thumb and forefinger to join the superficial arch or its branches. He also found the origin of the radialis indicis artery in 13% of hands from the radial side of the superficial palmar arch.

**J.D.Boyd et al (1956)** stated that the brachial artery ends in the middle of the cubital fossa by dividing, at about the level of the neck of the radius into the radial and ulnar arteries. It descends on the lateral side of the forearm. Then it turns downwards and backwards below the styloid process of the radius deep to the extensor tendons of the thumb. It passes downwards and inwards between the proximal ends of the first and second metacarpal bones and two heads of first dorsal interosseus muscle and it traverses the adductor pollicis muscle to enter the palm. In the palm it ends by anastomosing with the deep division of the ulnar artery to form deep palmar arch. On the anterior aspect, the radial artery gives superficial palmar branch which anastomoses with superficial division of the ulnar artery to form superficial palmar arch.

**J.C.B. Grant, James Couper Brash (1957)** have described that the radial artery is the smaller of the two terminal branches of brachial artery but it is more direct line with the parent trunk . Begins in the cubital fossa opposite the neck of radius and ends in the palm of the hand by anastomosing with the deep branch of the ulnar artery and thus completing the deep palmar arch. He also pointed out that the radialis indicis artery not uncommonly anastomoses with the superficial palmar arch. He also indicated that, the radial artery may be absent, its place being taken by branches of the ulnar or interosseous arteries. It may end in muscular branches in forearm or as the superficial palmar or in carpal branches.

The radial artery may run a superficial course, or and especially when it arises at a more distal level then usual, sometimes it passes to the back of the

wrist across the brachioradialis and it may lie superficial to the extensor tendons of the thumb, instead of deep to them. Its branches may be diminished or increased in number. The radial recurrent may spring from the brachial or ulnar arteries. The princeps pollicis and radialis indicis arteries may be absent, their places being taken by branches of superficial arch. The superficial palmar arch is sometimes absent, its branches are then given off from the deep arch. The deep palmar branch of the radial artery is much more rarely absent than the superficial arch. When absent its branches are given by superficial palmar arch.

**Arnold K. Henry (1957)** has told that the radial artery begins at the medial side of the biceps tendon and the artery is bound by fascia to pronator teres.

**Russell T. Woodburne (1957)** has described in his "Essentials of Human Anatomy" that a high origin of the radial artery from the brachial or even from the axillary artery, occurs in 15% of cases. The radial recurrent artery arises just below the origin of radial artery. The superficial palmar branch passes over or through the muscles forming the eminence of thumb. The superficial palmar artery is usually slender.

The deep palmar arterial arch is formed by the terminal portion of the radial artery in conjunction with the deep branch of ulnar artery and the branches of deep palmar arch are, the arteria princeps pollicis, the arteria radialis indicis, 3 palmar metacarpal , recurrent carpal and dorsal perforating branches.

**R.D.Lockhart et al (1959)** said that the brachial artery lying on brachialis in the cubital fossa, divides opposit the neck of the radius into the radial artery, its more direct continuation and the ulnar artery.

The radial artery, crossing the tendon of biceps , descends medial to the radial nerve, undercover of the belly of brachioradialis and having crossed supinator, pronator teres and flexor digitorum sublimis continues over the flexor pollicis longus and it crosses the floor of the anatomical snuff box on the scaphoid and trapezium passing deep to extensor pollicis longus, it reaches the proximal end of the space between the first and second metacarpal bones and turning forwards between the two heads of the first dorsal interosseous muscle, enters the palm between the two heads of adductor pollicis. There it gives origin to the princeps pollicis and radialis indicis and continues as the deep palmar arch. Just above the wrist it gives superficial palmar branch which crosses or penetrates the thenar muscles and may complete the superficial palmar arch.

**Sir Solly Zuckerman (1961)** has mentioned that the superficial palmar arch is completed laterally by a branch from one of the terminal branches of the radial artery either the superficial palmar branch of the radial artery, a small vessel which passes over the thenar muscles from the point where the radial artery turns backwards behind the tendons of the muscles of the thumb to the back of the wrist, or a branch from either the princeps pollicis artery or the radialis indicis artery which are branches of the main terminal part of the radial artery,

when it returns to the deep aspect of the palm. Sometimes the princeps pollicis and radialis indicis arteries arise by a common stem.

**Coleman S.S. and Anson B.J. (1961)** said that the superficial palmar arch is completed by a superficial branch of radial in about 35% of hands. In 37% the superficial branch of radial artery ending in thumb muscles. In 18% of hands the first dorsal metacarpal artery passed between the thumb and forefinger to join the superficial palmar arch or its branches. They listed the arch as incomplete when it did not send a branch to the thumb and index finger, more than half of their 21.5% of incomplete arches were of this type.

Regarding deep palmar arch they reported a few instances in which the arch was incomplete with the radial artery supplying the thumb and radial side of the index finger, or doing this and ending by anastomosing with a perforating artery from a dorsal metacarpal, while the ulnar end of the arch was formed by the deep branch of the ulnar and another perforating artery. They found one case also in which the deep arch was formed entirely by the deep ulnar and a perforating artery, there being no deep branch of the radial artery.

**J.A.Keen (1961)** has pointed out that among 284 dissections the superficial brachial artery including those which continued as superficially placed radial and ulnar arteries was found 35 times (12.3%). He also pointed out that the level of bifurcation of the brachial artery was related to the level of the radio-humeral joint. Among 284 dissections a “superficial radial artery” was seen three times (1%). In one individual the whole radial artery became superficial

about the middle the forearm as far as the first interosseous space. The third instance was on right side only.

**Sir John Bruce, Robert Walmsley, James A. Ross (1964)** described about the course of the radial artery as that, in the proximal two thirds, it lies undercover of brachioradialis and in the proximal third lies on the supinator. In the middle third it lies on the pronator teres and the radial head of the flexor digitorum superficialis. The distal third of the artery is subcutaneous and lies upon the flexor pollicis longus, the pronator quadratus and the radius. It gives radial recurrent artery near its origin. The superficial palmar branch runs through or superficial to the short muscles of thumb and sometimes joins the terminal part of the ulnar artery to complete the superficial palmar arch.

He also stated that when the radial artery is wounded at the wrist, both ends must be ligatured owing to the free anastomosis in the hand.

**G.J.Romanes (1964)** stated that the radial artery which is a branch of brachial artery given off in the cubital fossa opposit the neck of radius, smaller than the ulnar, is in more direct line with brachial artery. It ends by anastomosing with the deep palmar branch of the ulnar artery, thus completing the deep palmar arch. The superficial palmar branch usually pierce the muscles of the thenar eminence, and ends either in their substance or by joining the ulnar artery to complete the superficial palmar arch.

He also noted that “high division” of the brachial artery occurs most commonly in the proximal third of the upper arm. When high division occurs, the radial branch may pierce the deep fascia near the bend of the elbow and

descend in the forearm in the superficial fascia or it may pass behind the tendon of biceps. He also mentioned that the radial artery may arise from the axillary artery and it may pass to the back of the wrist superficial to the extensor tendons or it may lie on the superficial fascia of the forearm. The superficial palmar arch is completed by superficial branch of the radial or by the radialis indicis or the princeps pollicis artery.

**Ben Pansky, Earl Lawrence House (1964)** in their review of 'Gross Anatomy' mentioned, that the radial artery extends from the neck of radius to medial side of radial styloid process.

**Ernest Gardner, Donald J Gray, Ronan O' Rahilly (1967)** told that the radial artery is the smaller terminal division of the brachial artery and begins in the cubital fossa, opposite the neck of radius. The radial artery varies and it may be absent, it may arise in the arm, or even from the axillary artery. Occasionally, it runs a very superficial course throughout the forearm. The completion of the superficial palmar arch on the radial side is extremely variable. Commonly the superficial palmar arch was completed by the radialis indicis, by the superficial palmar branch of the radial, or by the princeps pollicis. A large median artery may contribute to it.

**W. Henry Hollinshead (1969)** described that the radial artery is in its course the more direct continuation of the brachial artery and it has the usual course.

The deep palmar arch is the chief continuation of the radial artery into the hand and is described as being, with the smaller princeps pollicis, one of the terminal branches of the radial, or as giving rise to the princeps.

**Barry J. Anson, Chester B.Mcvay (1971)** described that the radial artery runs a fairly straight course through the formation and terminates by takes part in the forearm of the deep palmar arch and because the artery is superficial, ligations of the radial artery is performed readily at any part of its course in the forearm. It gives radial recurrent artery near its origin. In ligation in the upper third of the forearm the artery is found deep to the interval between the brachio radialis and pronator teres muscle.

For ligation of the artery at the wrist an incision is made over the artery midway between the outer border of the radius and the tendon of the flexor carpi radialis. The vessel lies upon the pronator quadratus muscle.

**Richard S. Snell (1973)** said that the radial artery is the smaller of the terminal branches of the brachial artery. It begins in the cubital fossa at the level of the neck of radius. He also described that the deep palmar arch is a direct continuation of the radial artery and on entering the palm, the radial artery gives off the arteria radialis indicis and the arteria princeps pollicis.

**W.J.Hamilton (1976)** stated that the radial artery is accompanied by the superficial division of the radial nerve on its lateral side and traverses the lateral part of the wrist by passing backwards below the styloid process of radius and enters palm in between the proximal ends of the $1^{st}$ and $2^{nd}$ metacarpal bones and in the palm it ends by anastomosing with deep division of the ulnar artery to form deep palmar arch.

**J.P.Mall et al (1976)** in their article “Arterial pattern of brachial artery in relation to brachial plexus” mentioned the anomalous patterns of brachial artery which they found in 33.4% cases in 96 limbs dissected. The patterns are

1. Those “superficial brachial arteries” which continue into the cubital fossa and then bifurcate as usual (2.1%)

2. Those “superficial brachial arteries” which join to radial artery (2.1%)

3. Those “superficial brachial arteries” which continue as the radial artery, called high origin of the radial artery (2.1%)

**Keith L. Moore (1980)** has described that the radial artery begins in the cubital fossa just medial to the biceps brachii tendon at the level of the neck of radius. The radial recurrent branch arises from lateral side of radial artery just distal to its origin. As it crosses the floor of the anatomical snuff box it lies on the scaphoid and the trapezium and ends by completing the deep palmar arch in conjunction with the ulnar artry. The common place for taking the pulse is where the radial artery lies on the anterior surface of the distal end of the radius lateral to the tendon of the flexor carpi radialis muscle. Here it is covered only by deep and superficial fasciae, skin.

**Erlandson et al (1981)** has given the frequency of normal anatomic variations of upper extremity arteries as follows:

Sub clavian artery:-

Anomalous origin from the aortic arch 2%

Axillary / brachial / radial / ulnar arteries

High origin of radial artery 14%

1. From axillary artery 12%
2. From brachial artery 2%

High origin of ulnar artery 3%

| **Palmar Arch:** | | **Incomplete palmar arch 20%** |
|---|---|---|
| Complete palmar arch | 80% | Radial and ulnar arch 3% |
| Ulnar and radial artery origin | 36% | Ulnar artery origin only 13% |
| Ulnar artery origin only | 37% | Other 4% |
| Others | 7% | |

**Wilson SE. Stabie BE, Williams R.A. Olwen MC (1982)** mentioned that in the upper extremity, the radial artery has been chosen by most surgeons to be the primary choice for construction of an arteriovenous graft.

**Priver, Lysenbov, Bushkovich (1985)** have described that the princeps pollicis branches off the radial artery as soon as the latter penetrates the first interosseous space on the palm of the hand. It runs over the palmar surface of the first metacarpal bone and divides into branches, digitales palmares, to both sides of the thumb and to the radial side of the index finger.

**Ugawa, Ikeda (1985)** studied about the arterial patterns of the hands in primates (13 macaca fuscates) and they observed that in the dorsum of the hand, there are four dorsal metacarpal arteries. The $1^{st}$, $2^{nd}$ and $3^{rd}$ dorsal metacarpal arteries arise from the radial artery, while the $4^{th}$ one originates from the ulnar marginal artery. The radial artery lies in the inter muscular cleft of the lateral side of the forearm. At the wrist, the radial artery courses

diagonally into the dorsum of the hand from a point a little beyond the styloid process of radius.

The deep palmar arterial arches are formed by the perforating branches of the 2nd dorsal metacarpal artery and are usually composed of two proximal arches (C. volaris proximalis and a. volaris profundus) and one distal arch (C. volaris distalis). Volaris profundus (Deep palmar arch in man) follows the course of deep branch of ulnar artery and then divides terminally into radial and ulnar branches. The superficial palmar arterial arch is formed by the distal curved portion of the ulnar artery and completed by the superficial palmar branch of the radial artery.

**Poteat WL (1986)** reported a case of unilateral absence of the radial artery. The arterial system of the specimen was developmentally primitive with the anterior interosseous artery the chief blood supply to the forearm and hand.

**Kanaga suntheram, Sivananda Singham, Krishnamurti (1987)** said that the radial artery is the other terminal branch of the brachial artery. It extends from the neck of the radius to the medial side of the styloid process of the radius which is the first part and from distal part of styloid process it proceed towards the first interosseous space. This forms the second part of the course of the artery.

The third part of artery enters the palm by passing between two heads of the first dorsal interosseous muscle. In the palm, it gives off the princeps pollicis artery which divides into two to supply the medial and lateral sides of the thumb. Then the radial artery gives off the radialis indicis artery to the

lateral side of the index finger. After this, the radial artery curves medially and continues as deep palmar arch which is completed on the medial side by the deep branch of the ulnar artery.

**Michael Sachs (1987)** during the clinical investigations of 570 soldiers, found that the radial artery pulse was not felt in 5 cases at the typical place. In these 5 cases, he was able to feel a subcutaneous artery which coursed superficial to the anatomical snuff box and crossed superficial to the tendon of extensor pollicis longus muscle.

The radial artery divides in the distal fourth of the forearm (5-7cm proximal to the wrist joint) into two branches. The dorsal branch courses subcutaneously over the tendon of the brachioradialis muscle, and runs over the tendon of the extensor pollicis longus muscle to enter the deep aspect of the palm in the first metacarpal space. This dorsal branch courses parallel to the superficial branch of the radial nerve. The palmar branch can be regarded as the 'normal' radial artery which continues along the medial border of the brachioradialis muscle and courses deep under the tendons of the dorsal muscles of the thumb.

**John V. Basmasjian, Charles E.Slonecker (1989)** described that the trunk of radial artery is not crossed by any muscle, but the brachio radialis is lateral and overlaps it. The flexor carpi radialis is medial in distal two-thirds, immediately behind it are 6 muscles that clothe the anterior aspect of the radius and beyond these are the distal end of the radius and the capsule of the wrist joint. The artery gains the dorsum of the wrist by passing below the styloid process and

deep to the abductor pollicis longus. Here the radial artery gives an important nutrient artery to the scaphoid bone. The radial artery continuation in the palm is completed by the deep branch of the ulnar artery and forms deep palmar arch.

**Yao. JST (1989)** stated that occlusion of the radial artery, in particular is common following direct penetrating or blunt trauma or from transarterial catheters for arterial pressure monitoring or blood gas analysis. Patients with an incomplete palmar arch are at an increased risk of developing chronic hand ischaemia due to injury of the radial or ulnar artery.

**Mezzogiorno et al (1994)** from their study of 60 vascular casts of upper extremity found that the deep palmar circulation is constituted by the deep palmar arch. In most cases this is a complete arch formed by the radial artery and its continuation to a deep branch of the ulnar artery. In a few cases, the deep palmar ciculation is formed only by the radial or the ulnar artery. Only rarely is there a complete absence of the deep palmar arch. Four anatomic patterns were identified. (Table-1)

1. Radio ulnar (66.67%)
2. Radial anastomotic (21.67%)
3. Radial (8.33%) and
4. Ulnar (3.33%)

Two distinct types of the radio ulnar variant were observed, a proximal and a distal one, named according to the origin of the deep palmar branch.

**William J. Zwiebel (1995)** described the more commonly encountered variants of upper limb as follows.

1. Radial artery origin from the axillary artery 1-3%
2. Each division of the brachial artery
    a. High origin of the radial artery 19%
    b. Accessory (duplicated) brachial artery.
3. Ulnar artery origin from brachial or axillary artery 2-3%
4. Low origin of ulnar artery < 1%
5. Persistent median artery 2-4%

**Omori o et al (1996)** during the dissection course of Kobe university school of medicine, they found bilateral superficial brachial arteries that continued to the radial arteries.

**Celik H.H., Sargon MF, Konan A, Kural. E (1996)** described that high division of the brachial artery was observed in 2 cadavers during routine dissection of upper extremities. In the first case, the brachial artery of the right upper extremity divided into two terminal branches immediately after passing between the lateral and medial roots of the median nerve and just below the origin of profunda brachial artery. The lateral branch was the radial artery.

In the second case, the brachial artery was divided into its two terminal branches just below the origin of the profunda brachial artery.

**Renan Uflacker (1997)** stated that the radial artery is the more direct continuation of the brachial artery, arising about 1cm below the bend of elbow coursing along the radius bone, reaching the hand. There are three main parts

of the radial artery one in the forearm, one at wrist, and one in the hand. The radial artery may originate at the axillary or upper part of the brachial artery which he mentions as variation.

**Nunoo – Mensah (1998)** mentioned that the absence of the ulnar artery was responsible for hand ischaemia after radial artery grafting for coronary bypass.

**P.H. Grossman et al (1998)** stated that the radial forearm flap is a workhorse for coverage of soft tissue defects of the hand, when distally based; it can be based proximally to cover defects in the elbow region (fig – 8). The radial forearm fascial flap without inclusion of overlying skin, avoids donor-site morbidity and provides a pliable and thin coverage for the recipient defect.

The radial forearm fascial flap is ideally suited for reconstruction of soft tissue defects of the hand, when thin, pliable coverage is needed and long periods of immobilization are contra indicated. The flap is thin enough to have proven very satisfactory for resurfacing the thumb & complete palmar arch with good retrograde flow into the radial artery, is a pre requisite for the distally based flap (fig – 9, 10, 11,).

**Brian F. Buxton (1998)** mentioned that the radial artery has a number of anatomical variations. The most common and important variation is the high origin of the radial artery which occurs in 14% of upper limbs.

In these, the radial artery is found to originates in the proximal half of the brachial artery in 11% with 2% arising from the axillary artery and 1% from the distal and upper brachial artery above the cubital fossa.

The ‘classic’ type of superficial palmar arch, in which the superficial branch of the radial artery joins the superficial palmar arch of the ulnar artery, was found to be relatively uncommon 12.5%. The complete deep palmar arch, in which continuity exists between the deep palmar branches of the radial and ulnar arteries, was found in 87.5% of hands. The radial artery has a relatively higher prevalence of intimal disease compared with the interal thoracic artery. Ultrasound examination of the radial artery is therefore, desirable to identify arteries that have intimal plaques and calcification.

Ultrasound examination of the forearm arteries identifies diseases in the ulnar artery and any anatomical variations of the radial artery, such as a high origin from the brachial artery.

**Kulshrestha P et al (1999)** stated that the use of the radial artery as a conduit for coronary artery bypass grafting has several technical advantages; the artery is approximately 20 cm long; it has a diameter greater than that of the internal mammary artery; it is normally subjected to systemic blood pressure; it has thick and resistant walls; and it is rarely affected by atherosclerosis (fig – 12, 13).

**Gianfederic Ponsati, Mario Gaudino (2000)** stated that the radial artery was re-introduced in coronary artery bypass surgery in the early 1990s and, due to its favourable anatomical position, caliber and length, soon gained good popularity. They have also mentioned that from a histological point of view the radial artery is a thick walled muscular artery, whose vascular wall is irrorated at least part by vasavasorum and characterised by a high number of

discontinuities of the internal elastic lamina. The abundant muscular component of the radial artery is the anatomical background of the hyper spastic attitude of the artery.

**D.Eugene Strandness (2001)** stated that occlusion of the radial artery, in particular is common following direct penetrating or blunt traumas or from transarterial catheters for arterial pressure monitoring or blood gas analysis. Patients with an incomplete palmar arch are at an increased risk of developing chronic hand ischaemia due to injury to the radial or ulnar artery. Microembolism to the radial, ulnar or digital arteries can also produce chronic hand and or digit ischaemia.

**Malcic – Gurbuz-J, Gurunlooglu. R. Ozdogmus Yalin – A (2002)** reported a trifurcation of the brachial artery that divided into radial, ulnar and superior ulnar collateral arteries high in the arm.

**Durgun B, Yucel AH, Kzil Kenat, Dere F (2002)** Presented a case report of multiple arterial variations involving the arteries of the upper limb in a single cadaver. On the right side, the sub scapular artery gave rise to a large posterior circumflex scapular arteries. On the left side, the radial and ulnar arteries arose from the brachial artery at the level of arm, with their origin being opposite to the usual arrangements. There was an arciform anastomosis between the radial and ulnar arteries with the radial recurrent arteries arising from the concavity of the arch. The course of both the radial and ulnar arteries was normal at the wrist and hand, except for the absence of the first palmar metacarpal artery and an early bifurcation of the second palmar metacarpal artery.

**M.Rodriguez – Nied enfuhr et al (2003)** reported that the superficial radial artery coursing over the tendons defining the snuff box. This is a rare finding with an incidence around 0.4% of adult upper limbs (2/480 dissections)

The absence of the radial artery has been rarely reported with an estimated incidence lower than 0.2% (<1/480 dissections). In those cases, the radial blood supply territory was provided by the anterior intereosseous or the median artery.

**John Gourassas et al (2003)** presented a case report of a patient with a failed radial coronary angiography approach, due to the anomalous origin of the radial artery from the brachial artery. The radial artery was hypoplastic and exhibited a severe spasm resistant to vasodilators

**Bilodi AK, Sanikop MB (2004)** studied 20 human upper limbs during routine dissection and found trifurcation of brachial artery in left limb of one specimen. Here the brachial artery terminated into ulnar and radial arteries and the common interosseous artery in the left upper limb. In the right upper limb of the same body, the brachial artery terminated into ulnar and radial arteries and the common interosseous were arising from the radial artery but not from ulnar artery.

**Mary L. Brandt M.D., Stuart Goldstein MD (2004)** says that chronic haemodialysis access can be obtained in children by creation of a primary arteriovenous fistula. Primary fistulae are most commonly created between the radial artery and cephalic vein at the wrist.

**Robert B. Rutherford (2005)** classified the superficial volar arch as complete arch 80% or an incomplete arch 20% The deep volar arch is formed primarily by the radial artery which goes on to anastomose with the deep volar ramus of the ulnar artery. It has less variability than the superficial volar arch. The deep volar arch can either be complete (97%) or incomplete (3%)

**Vollala VR, Rao M, Prasad Deepthinath (2005)** reported multiple variations in external pattern of upper extremity of a female cadaver.

1. Presence of an anastomotic artery which connected brachial artery to the radial artery.

2. Radial artery passed deep to the tendon of biceps brachii in the cubital fossa.

3. Median artery arose directly from ulnar artery and pierced the median nerve.

4. Formation of superficial palmar arch by superficial branch of ulnar artery and the median artery.

# ***Developmental Anatomy***

# DEVELOPMENTAL ANATOMY

## DEVELOPMENTAL ANATOMY OF UPPER LIMB VASCULATURE

### Normal Development

When the upper limb buds are formed in the 4th week of intrauterine life, a number of small arteries arise from the dorsal aorta and pass into the limb bud to form capillary network which drain into the anterior cardinal veins. Out of these small arteries, only one persists as the axis artery of the upper limb and it shifts its origin to the lateral branch of the 7th cervical inter segmental artery.

This trunk is the axis artery which is divisible into sub clavian, axillary, brachial and anterior interosseous segment which extends upto the level of carpus where it terminates as a deep plexus in the developing hand. A branch from the main trunk passes dorsally between the early radius and ulna as the posterior interosseous artery (fig – 14).

A second branch accompanies the median nerve into the hand, where it ends in a superficial capillary plexus. The radial and ulnar arteries are the latest arteries to appear in the forearm. At first the radial artery arises more proximally than the ulnar, crosses in front of the median nerve, and supplies biceps. Later, the radial artery establishes a new connection with the main trunk at or near the level of origin of the ulnar artery and the upper portion of the original stem usually largely disappears. On reaching the hand, the ulnar artery links up with the superficial palmar plexus, from which the superficial palmar arch is derived. While the median artery commonly loses its distal connections

and is reduced to a small vessel. The radial artery passes to the dorsal surface of the hand, but after giving off dorsal digital branches, it traverses the first inter metacarpal space and joins the deep palmar arch.

M. Rodriguez – Niedenfuhr, Varquez Parkin described in their new theory, that the formation of the arterial system in the upper limb takes place as a dual process. An initial capillary plexus originating from the dorsal aorta enters the limb bud during stage 12 when the limb bud begins its out growth. Thin plexus develops at the same rate as the limb. At stage 13, the capillary plexus begins a maturation process involving the enlargement and differentiation of selected canals. This remodeling process starts in the aorta and continues in a proximal to distal sequence. By stage 15, the differentiation has reached the subclavian and axillary arteries , by stage 17 the brachial artery as far as the elbow, by stage 18 the forearm arteries except for the distal part of the radial and finally by stage 21 the whole arterial pattern is present in its definitive morphology.

**Embryological justification of the existence of the arterial variations in the adult upper limb**

Based on the results of Rodriguez Nilenfuhr et al 2001, injection studies on animal embryos and experimental data which showed that when an endothelial tube gets a muscular coating it looses its remodeling ability. The sprouting theory described in many of the embryological and anatomical text books and reproduced in (fig – 15) was absolute. The new findings suggest that the arterial pattern of the upper limb develops from an initial capillary plexus

by a proximal to distal differentiation of certain capillary vessels, and the regression of others (fig – 16). It is suggested that the persistence, enlargement and differentiation of capillaries forming the initial capillary plexus, which would normally remain in a capillary state or even regress, give rise to arterial variations of the definitive arterial pattern, rather than the sprouting of aberrant vessels.

The establishment of the superficial brachial, accessory brachial and the brachial part of those variation affecting the arm and forearm must be determined before stage 17 as then, the arteries until the elbow would have already got a definitive morphology of its wall and no further remodeling would be possible. The variations affecting the forearm arteries as well as the ante-brachial part of these variations affecting the arm and forearm, have to be established before stage 18 as then the forearm arteries have got their definitive wall morphology except the distal part of the radial. The superficial radial and the distal part of the superficial brachial radial arteries would be determined before stage 21 when they get their definitive morphology (fig.16)

# *Materials and Methods*

# MATERIALS AND METHODS

## STUDY MATERIALS

The study materials consist of

a) 50 upper limb specimens from 25 adult cadavers (19 males, 6 females)

b) 2 clinical cases.

## METHODS OF STUDY

I. Conventional dissection method in adult cadavers after injecting red oxide.

II. Adult cadaveric Angiographic study.

III. Clinical study

a) by angiography

b) by doppler study

IV. Histological study.

### I. Conventional dissection Method

25 Adult human cadavers were selected from the cadavers allotted to the I MBBS students at the Institute of Anatomy, Madras Medical College.

Red Oxide dye preparation:-

The red oxide with melted bull's fat was injected as a method for better identification of the branches of the radial artery. This injecting medium was prepared by mixing the bull's fat, turpentine oil and vegetable oil in the proportion of 2:1:1. Red oxide powder was added for colouring. First the bull's fat was melted in a thick bottomed vessel to which red oxide powder was added

and mixed thoroughly. The turpentine oil and vegetable oil were added to the above mixture to prevent the bull's fat from solidifying quickly.

Now the axillary artery was exposed by making a small skin incision just below the clavicle in the lateral aspect. A small caliber metal cannula was introduced through a linear incision on the arterial wall about 3cm. into the artery. Then the axillary artery was ligated proximal to this.

About 20-30ml of the mixture was then loaded in as metal syringe when it is still hot and in liquid form and injected into the cannula and the specimen was allowed to settle down for at least 6 hours before carrying out the dissection on it.

The skin and superficial fascia over the flexor aspect of arm were reflected by making a transverse incision at the middle part of arm and the incision was extended to the forearm, palm over the flexor aspects as shown in the (fig – 17).

The skin over the dorsum of hand was also carefully reflected along the conventional anatomical lines. Then the deep fascia was removed, flaps reflected to uncover biceps brachii muscles and its tendon, aponeurosis and brachio radialis muscles. The brachio radialis muscle was slightly displaced laterally.

The principal neurovascular bundle of the forearm in the cubital fossa was identified. Then the structure in this fossa were traced proximally up to the lower 1/3 of the arm. The neurovascular bundle consists of the brachial artery and its 2 terminal branches radial and ulnar arteries with their two venae

comitantes. Then the radial artery was traced from its origin in the cubital fossa and then along the medial border of brachioradialis muscle in the upper 2/3 of forearm and traced to lower 1/3 of forearm upto styloid process of radius. In the lower part of its course, it lies just below the skin superficial and deep fasciae.

During the above procedure, the radial recurrent branch was identified along the posterolateral aspect of the radial artery just distal to its origin. It ascends between the brachioradialis and brachialis muscles and on the supinator. It was traced above up to its anastomosis with radial collateral artery which is a branch of profunda brachii artery. Few muscular branches were traced in the forearm. Palmar carpal branch traced from its origin from the radial artery near the distal border of pronator quadratus muscle.

The superficial palmar branch was traced just proximal to the wrist, which passes through the muscles of thenar eminence and then it was traced up to its anastomosis with the terminal part of ulnar artery to form the a superficial palmar arch. A slender dorsal carpal branch arose from the radial artery deep to extensor pollicis tendons was noted in all the 50 specimens.

Just before the radial artery passes between the heads of 1$^{st}$ dorsal interosseous muscle, the first dorsal metacarpal artery was given off from the radial artery which was very thin.

From the lateral part of wrist, the radial artery was traced dorsally which goes deep to the tendons of abductor pollicis longus and extensor pollicis brevis. Then it was traced in the floor of the anatomical snuff box up to its

entry into the palm by passing between the heads of the first dorsal interrosseous muscle. Then the princeps pollicis artery was dissected in the first inter digital cleft in the palmar side and its 2 divisions were also identified along both sides of thumb in the palmar aspect.

Another branch, the arteria radialis indicis was also traced just nearer to the arteria princeps pollicis and was cleared up to the radial side of the index finger. Then the terminal part of the radial artery was dissected inbetween the two heads of the adductor pollicis muscle upto the base of the 4$^{th}$ metacarpal bone where it joins with the deep branch of ulnar artery to complete the deep palmar arch. The convexity of this arch is towards the digits and this arch is situated proximal to the superficial palmar arch. The deep branch of ulnar nerve lies in the concavity of this arch. During the above cadaveric dissection in the adult upper limbs, the variations of the radial artery and its branches were photographed for documentation. The findings of the observation were noted down as per the parameters taken for this study.

## II. Adult Cadaveric Angiographic Study

2 disarticulated upper limbs were taken to the Barnard Institute of Radiology, Government General Hospital, Chennai – 3 and under the guidance of radiologist, the urograffin solution (contrast) was injected into the brachial artery which was exposed in the cubital fossa by making a small incision over that part. Then the branching pattern, course of the radial artery were studied by visualising the pictures taken serially under fluoroscopic monitoring starting

from 5 minutes after injecting the contrast. Then the conventional dissection was carried out in these limbs.

## III. CLINICAL STUDY

2 Clinical cases from the Vascular Surgery Department, Government General Hospital, Chennai –3 have been selected with the age of 30 and 35 years with the following diagnosis

| Sl.No. | Sex / Age | Diagnosis |
|---|---|---|
| 1 | male / 30 | Ulnar artery occlusion |
| 2 | male / 35 | Pseudoaneurysm of radial recurrent artery. |

In the above two cases the branching pattern of the radial artery was observed by the angiographic study.

### Angiographic Procedure

### Retrograde axillary artery Catheterization

First the patient was put in supine position. Then the left arm was abducted to the extreme and the hand was placed under the patient's head. The puncture site of the axillary artery was located along the lateral axillary fold over the proximal part of the humerus so that the underlying bone provides support during compression.

The axillary artery was palpated and fixed by the left index and middle finger. Under local anesthesia, a small superficial skin nick was made with a no. 11 blade directly over the arterial pulse. The course of the artery was palpated while a 18 gauge needle (Pott's Cournaud Needle) having a sharp

stylet with a perforated hub was rapidly thrust down the artery. The needle was angled at 45° with respect to the skin and gently advanced. When arterial blood was seen exiting from the stylet hub, the hub was removed and catheter (seldinger) with two way tap attached to its hind end was passed along the guide wire into the artery. The wire should not be forced.

Now, the urograffin solution (contrast) was injected to identify the course of the vessel and to find out the clinical problems like thrombosis, embolism, atheromatous plaque, stenosis or abnormal dilatations namely aneurysm. The study was done by visualising the pictures taken serially starting from 5 minutes after injecting the contrast. Then the branches of brachial artery were noted.

**Doppler Study Procedure**

A male patient aged 40 years was selected from Vascular Surgery Department, Madras Medical College who complains of pain and numbness over right upper limb for a prolonged time.

Doppler study is the non – invasive, has a high over all accuracy, is atraumatic and comfortable to the patient, can be performed quickly, and does not require bulky equipment or long set up procedure. In the continuous – wave doppler blood flow device the sound source is a small probe housing one transmitting and one receiving crystal. Red blood cells reflect ultrasound impulses, and the frequency of the reflected wave is shifted to either a higher or lower pitch depending on the flow velocity, as described by the doppler equation. The probe is placed against the skin and is coupled by means of a

water soluble acoustic gel, which serves to eliminate air pockets and ensure optimal acoustic transmission and reception. The transmitted sound waves strike the red corpuscles and bounce back. The reflected signals are shifted in pitch, either higher or lower, depending on the relative velocity. The signals are than fed to outputs that convert them to audible sound and also are fed to quadrature outputs for spectrum analyzers and zero crossing strip chart devices. Color doppler flow imaging systems analyse returning echoes from both tissues and the moving red blood cells within the lumen.

Doppler study of the radial artery is done by placing the probe over wrist on the anterior surface over radial side (fig – 18) and the waveforms are recorded to identify the amount of blood flow and to find out the clinical problems like arterio – venous fistula, arterial aneurysm and arterial stenosis.

The study was done by monitoring the pictures on the monitor and by studying the picture printout.

**IV. HISTOLOGICAL STUDY**

5 bits of radial artery from the upper limb and 5 bits of coronary artery from the heart of 5 fresh cadavers were taken. The bits were processed and the sections were stained with eosin and haematoxylin and studied under light microscope. The structure of both arteries were photographed and documented.

## Histological Study - Procedure

**Fixation in 10% Formalin**

↓

**Dehydration with graded alcohol**

↓

**Cleaning with xylol**

↓

**Impregration with wax**

↓

**Embedding**

↓

**Sectioning**

↓

**Mounting of sections**

↓

**Staining**

## STAINING PROCEDURE

***DEPARAFFINISATION***

↓

***Hydration in Graded Alcohol***

↓

**Staining**

↓

**Haematoxylin & eosin Staining**

↓

**Cytoplasm - Pink**
**Nucleus - Purple**

**Decolourisation**

↓

**Differentiation**

↓

**Dehydration**

↓

**Cleaning**

↓

**Mounting**

# *Observation*

# OBSERVATION

The radial artery, its origin, course and its branching pattern were studied by the following methods.

I. Conventional dissection method in adult cadavers after injecting red oxide.

II. Adult Cadaveric Angiographic study

III. Clinical study a) by angiography b) by doppler study

IV. Histological study

## I. Adult cadaveric study

25 human adult cadavers were taken for study. There were 19 male and 6 female cadavers. After the conventional dissection was carried out, the findings were documented regarding the origin, course and branching pattern of the radial artery.

### 1. Origin of the radial artery

In all 50 upper limb specimens dissected in 43 specimens (86%) the origin of the radial artery is at the level of neck of radius (fig 19, 20). In 3 specimens (6%) the origin of the radial artery is at the intercondylar line (fig 21). In 4 upper limbs (8%) the origin of the radial artery from the brachial artery is above the intercondylar line (fig 22, 23, 24) (Table – 2).

In all the 50 limbs the radial artery appears to be the continuation of the parent trunk the brachial artery.

In 22 specimens (44%) the radial artery is the smallest of two divisions of the brachial artery. In 16 specimens (32%) the size of the radial artery is equal to that of the ulnar artery.

In 12 specimens (24%) the radial artery appears to be larger than the ulnar artery (Table – 3).

**2. Course of the radial artery**

Out of 50 specimens dissected, in 48 specimens (96%) the radial artery descends along the lateral side of forearm from the medial side of the neck of radius to the wrist. Proximally it is overlapped anteriorly by the belly of brachioradialis and after that it is covered only by skin, superficial and deep fasciae. The radial artery passes anterior to the tendon of biceps, supinator, the distal attachment of pronator and the radial head of flexor digitorum superficialis, flexor pollicis longus, pronator quadratus and the lower end of radius. Brachioradialis muscle is lateral to the radial artery throughout its length. Pronator teres is medial to the distal portion (fig – 25).

At the wrist the radial artery passes on to the dorsal aspect of the carpus passing deep to tendons of abductor pollicis longus and extensor pollicis brevis between the lateral carpal ligament and these tendons. Then it enters to the palm between the 2 heads of dorsal interosseus muscle (fig – 26) and passed medially under cover of oblique head of adductor pollicis and terminated by forming deep palmar arch.

In 2 specimens (4%) the radial artery was superficial in its course from the middle of forearm to the first interosseous space covered by skin, superficial fascia and traverses over the tendons of abductor pollicis longus and extensor pollicis brevis in the anatomical snuff box instead of going deep to them (Table – 4).

In 48 specimens, radial artery terminated by forming deep palmar arch, In 2 specimens, the radial artery ends by supplying adductor pollicis in its distal part.

**3. Branches**

In 50 specimens dissected, the branches of the radial artery namely the radial recurrent artery, superficial palmar branch, arteria princeps pollicis, arteria radialis indicis and other usual branches such as muscular branches, anterior carpal branch, dorsal carpal branch, first dorsal metacarpal branch were studied.

**a) radial recurrent branch**

In 44 specimens (88%) the radial recurrent artery arose from the radial artery close to the origin of the radial artery from the brachial artery (fig – 27).

In 3 specimens (6%) the radial recurrent artery arose from the radial artery just beyond its origin.

In 2 specimens (4%) the radial recurrent branch arose from the lateral side of the brachial artery just above the bifurcation into ulnar artery and radial artery (fig – 28).

In one specimen (2%) the radial recurrent artery arose from the brachial artery at the level of its bifurcation into radial and ulnar artery (fig – 29) (Table – 5).

**b) superficial palmar branch**

In all the 50 specimens dissected, the superficial palmar branch arose from the radial artery near the wrist joint before it turns towards dorsum.

In 26 upper limbs (52%) the superficial palmar branch passed over the thenar eninence and completed the superficial palmar arch joining with superficial branch of the ulnar artery (fig – 30, 31).

In 21 specimens (42%) the superficial palmar branch passed through the thenar muscles and completed the superficial palmar arch by joining with superficial branch of the ulnar artery.

In 3 specimens (6%) the superficial palmar branch was very slender and ends by supplying the thenar muscles. It was not involved in the completion of superficial palmar arch and the superficial palmar arch which was formed by the ulnar artery was incomplete in 2 specimens (fig – 32, 33) and the arch was completed by median artery in one hand (fig – 34) (Table – 6).

**c) Arteria Princeps Pollicis**

In 45 upper limbs (90%) the arteria princeps pollicis arose from the radial artery after it entered into the palm, by passing in between two heads of the dorsal interosseous muscles (fig – 35).

In 2 specimens (4%) the princeps pollicis arose from the superficial palmar arch (fig – 36).

In 2 specimens (4%) the arteria princeps pollicis arose from the radial artery in the dorsal side before it enters into the first interdigital cleft (fig 37). the arteria princeps pollicis passes to the palmar side of the thumb and divided into two branches to supply both sides of thumb.

In one specimen (2%) the arteria princeps pollicis arose from the superficial palmar branch of radial artery over thenar eminence and divides into two branches to supply both sides of thumb (fig 38) (Table – 7).

**d) arteria radialis indicis**

In 47 specimens (94%) the arteria radialis indicis arose from the radial artery in the palmar side after it has given off the arteria princeps pollicis (fig – 35).

In 46 specimens it supplied only the radial side of the index finger and in one specimen the arteria radialis indicis supplies both sides of index finger.

In one specimen (2%) the arteria radialis indicis arose from the superficial palmar branch of the radial artery in the palm over thenar eminence and passed towards the radial side of the index finger (fig – 38).

In 2 specimens (4%) this branch arose from the superficial palmar arch and goes to supply the radial side of the index finger (fig – 36) (Table– 8).

**e. palmar carpal branch**

In all 50 specimens the palmar carpal branch was very small and found to arise from the radial artery near the radial border of pronator quadratus muscle (fig – 39).

**f. 1st dorsal metacarpal artery**

Just before the radial artery passes between the heads of 1st dorsal interosseous muscle, 1st dorsal metacarpal artery was given off from the radial artery which was very thin in all the 50 specimens.

**g. dorsal carpal branch**

A slender dorsal carpal branch arose from the radial artery deep to extensor pollicis longus tendon was noted in all the 50 specimens (fig – 35).

**h. origin of interosseous artery from the radial artery**

Apart from the usual branches from the radial artery, in one specimen (2%) the common interosseous artery arose from the radial artery (fig – 40, 41).

In one specimen (2%) the anterior interosseous artery arose from the radial artery (fig – 42).

**4. completion of superficial palmar arch**

In 50 specimens dissected, in 47 specimens (94%) the superficial palmar arch was completed by the superficial palmar branch of the radial artery and the superficial branch of the ulnar artery (fig – 43).

The superficial palmar arch was incomplete in 2 specimens (4%) Here the superficial palmar branch which usually complete the superficial palmar arch was very thin and ends by supplying thenar muscles and the ulnar artery terminated as incomplete arch (fig – 46).

In one specimen (2%) the superficial palmar arch was completed by median artery (fig – 45) (Table – 9).

In 2 specimens (4%) the arteria princeps pollicis and the arteria dorsalis indicis arose from the superficial palmar arch on its radial end.

**5. formation of deep palmar arch**

In 48 out of 50 upper limbs (96%) the terminal part of the radial artery passed medially undercover of oblique head of adductor pollicis, the digital flexor tendons, lumbricals and forms deep palmar arch by joining with the deep branch of the ulnar artery (fig – 47(A), 47(B)).

In 2 specimens (4%) the radial artery after giving arteria princeps pollicis and radialis indicis branches, travelled deep to the oblique head of adductor pollicis muscle and the deep palmar arch was incomplete (Table– 10).

**II. Adult cadaveric angiographic study**

The urograffin solution (contrast) was injected into the brachial artery of 2 disarticulated upper limb specimens and the branching pattern, course of the radial artery were observed by taking pictures serially under fluoroscopic monitoring starting from 5 minutes after injecting the contrast

solution. Normal branching pattern, course, deep palmar arch were observed in both limbs (fig 48, 49, 50, & 51).

## III. Clinical Study

**a. By Angiographic Study :** Two clinical cases were selected from Vascular Surgery Department, Government General Hospital, chennai-3 with the age group of 30 and 35 years.

| Sl No. | Age/Sex | Diagnosis |
|---|---|---|
| 1 | 30/ Male | ulnar artery occlusion |
| 2 | 35/ Male | Pseudoaneurysm of radial recurrent artery |

For the above cases brachial arteriogram was done as an investigation procedure. In case no. 1, ulnar artery occlusion was made out (fig 52). In case no. 2, pseudoaneurysm of radial artery in the upper part near radial recurrent artery was diagnosed (fig 53). In both cases the course of radial artery and the branching patterns were normal.

**b. by Doppler study**

In a male patient aged 40 years was selected from Vascular surgery Department for doppler study as an investigation procedure and the flow of blood in radial artery was noted which shows normal study (fig – 54, 55).

## IV. Histological Study

5 bits of radial artery and 5 bits of coronary artery measuring about 5 cm each were taken from a fresh cadaver and processed for histological study. The section were stained with eosin and haematoxylin and studied under light microscope and the structures of arteries were studied.

**Findings**

**Radial artery :-** Tunica intima, tunica media visualized. Internal elastic lamina separated from the endothelial layer by sub endothelial layer and separate the tunica media from the tunica intima.

Tunica media is made up of more muscular fibres which are seen with their nuclei. In between there are few elastic fibres seen. External elastic lamina and outer tunica adventitia with few vasavasorum seen (fig – 56).

**Coronary artery:** Consists of tunica intima, tunica media and tunica adventitia which have more or less similar findings with that of the radial artery (fig – 57).

# *Discussion*

# DISCUSSION

The present study of the radial artery was undertaken to study the variations in its level of origin, course, branching pattern, its contribution to superficial and deep palmar arches and its histological similarity with the coronary artery.

**I. ADULT CADAVERIC STUDY**

**1. ORIGIN OF THE RADIAL ARTERY**

**Henry Gray (1858)** described that the radial artery begins about 1cm distal to the bend of elbow (at the level of neck of radius).

**J.E.Frazer (1937)** mentioned that the radial artery arises in the cubital fossa opposite the upper part of the neck of the radius.

**C.Latimer Callander, Dean Lewis (1939), J.D.Boyd et al (1956), J.C.B. Grant, James Couper Brash (1957),** have described that the radial artery begins in the cubital fossa opposite the neck of the radius.

**R.D. Lockhart et al (1959), G.J. Romanes (1964)** also stated that the radial artery which is a branch of brachial artery given off in the cubital fossa opposite the neck of radius.

**Ernest Gardner et al (1967) , Ben Panksky, Earl Lawrence(1964), Richard S.Snell (1973)** described that the radial artery begins in the cubital fossa at the level of the neck of radius.

**Keith L.Moore (1980)** mentioned that the radial artery begins in the cubital fossa just medial to the biceps brachii tendon at the level of neck of radius.

According to **Kanagasuntheram, Sivananda Singham, Krishna murti (1987**) the radial artery extends from the neck of the radius. They had not given any statistical data regarding the origin of the radial artery. In the present study, in 86% of cases the origin of the radial artery is at the level of the neck of radius.

**Degaris and Swartley** (1928) stated that the incidence of high origin of the radial artery is 7.7%.

**Miller R.A. (1939)** quoted the high origin of the radial artery as 3%.

**McCormack et al (1953)** mentioned that the most common variation of the radial artery is the high origin which is about 77%.

**Russel T.Woodburne (1957)** said that high origin of the radial artery from the brachial artery or axillary artery is 15%.

**J.P. Mall et al (1976)** mentioned that he found high origin of the radial artery in 2.1%.

**Erlandson et al (1981)** said that the radial artery has high origin in 14% of cases.

**William J .Zwiebel(1995)** stated that high origin of the radial artery is in 19%.

**Brain F.Buxton (1998)** described that high origin of the radial artery is in 14%.

In the present study, the origin of the radial artery at the inter condylar line was in 6% of cases and the origin of the radial artery above the inter condylar line was in 8% of cases which are higher than the usual level of

origin. So high origin of the radial artery in the present study is 14%. The incidence of high origin in the present study coincides with that of Russel. T.Woodburne, Erlandson et al and Brain F. Buxton who have given the incidence of high origin of the radial artery as 15%, 14% and 14% respectively (Table – 11). The incidence of high origin of the radial artery in the present study is higher than that of Degaris and Swartley who has given the incidence as 7.7%. The incidence of high origin of the radial artery in the present study is also higher than the incidence given by Miller R.A. which was 3% and 2.1% which was given by J.P.Mall et al. The incidence of high origin of the radial artery in the present study is lower than the incidence given by William. J. Zwiebel which was 19%. The incidence of high origin of the radial artery mentioned by McCormack et al was 77% which is much higher than the present study.

**Henry Gray (1858), Thomas Walmsley (1934)** stated that the radial artery appears as the more direct continuation of the parent trunk.

**J.E.Frazer (1937), J. Parsons Schaeffer (1942)** said that the radial artery is at first continuous with that of the parent trunk.

**J.C.B.Grant (1957) R.A. Lockhart et al (1959), W.Henry Hollin shead (1969)** mentioned that the radial artery was direct continuation of the parent trunk.

In the present study, in all 50 specimens, the radial artery appears to be the direct continuation of the parent trunk.

**(a) Course of the radial artery**

**Henry Gray (1858)** described that the radial artery descends along the lateral sides of the forearm to the wrist. Proximally it is overlapped anteriorly by the belly of brachio radialis and distally covered by skin, superficial and deep fasciae At the wrist, the radial artery curls postero laterally round the carpus, beneath the tendons of abductor pollicis longus to the proximal end of the first inter meta carpal space, swerving medially between heads of the first dorsal interosseous into the palm and then crossing medially to form the deep palmar arch with the deep branch of the ulnar artery.

**George A Piersol (1930)** stated that the radial artery arose at the bend of elbow and passes down the lateral border of the forearm to the level of the styloid process of radius where it bends laterally and extends downwards over the dorsum until it reaches the interval between the first and second metacarpal bones and passes forwards into the palmar surface of the hand forming deep volar arch.

According to **J.Parsons Schaeffer (1942),** the radial artery runs along the radial side of the forearm as far as the styloid process and curving over the lateral side and back of the wrist, enters the palm between the bases of the first, second metacarpal bones and ends by anastomosing with deep branch of ulnar artery to form deep palmar arch, deep to the oblique head of adductor pollicis.

**J.D.Boyd et al (1956)** quoted that the radial artery descends on the lateral side of the forearm and it turns downwards, backwards, below the styloid process of

the radius deep to the extensor tendons of the thumb. Then it passes downwards and inwards between the proximal ends of first and second metacarpal bones and two heads of first dorsal interosseous muscle. Then it traverses the adductor pollicis muscle to enter the palm where it ends by anastomose with deep division of the ulnar artery to form deep palmar arch.

**R.D.Lockhart et al (1959)** mentioned that the radial artery, crossing the tendon of biceps, descends medial to the radial nerve under cover of the belly of brachio radialis and having crossed supinator, pronator teres and flexor digitorum sublimis, continuous over the flexor pollicis longus. Then it crosses the floor of the anatomical snuff box on the scaphoid and trapezium passing deep to extensor pollicis longus. Then the radial artery reaches the proximal end of the space between first, second metacarpal bone, turning forwards between two heads of first dorsal interosseous muscle to enter the palm. where it ends by forming deep palmar arch with the deep branch of the ulnar artery.

**Sir John Bruce, Robert Walmsley, James A. Ross (1964)** described about the course of the radial artery as that in the proximal two thirds, it lies under cover of brachio radialis and in the proximal third lies on the supinator. In the middle third it lies on the pronator teres and the radial head of flexor digitorum superficialis. The distal third of the artery is subcutaneous and lies upon the flexor pollicis longus, pronator quadratus and the radius.

**W.J. Hamilton (1976)** quoted that the radial artery is accompanied by the superficial division of the radial nerve on the lateral side and traverses the

lateral part of the wrist by passing backwards below the styloid process of radius and enters palm in between the proximal ends of the first, second metacarpal bones in the palm. Then it passes medially, ends by anastomosing with deep division of the ulnar artery to form deep palmar arch.

According to **Kanagasuntheram, Sivanandhasinghasm, Krishnamurti (1987),** the radial artery extends from the neck of the radius to the medial side of the styloid process of the radius and from the distal part of the styloid process it proceeds towards the first interosseous space. Then it enters the palm by passing between two heads of the first dorsal interosseous muscle and curves medially continuous as deep palmar arch which is completed on the medial side by the deep branch of the ulnar artery.

**John V Basmajian, Charles E Slonecker (1989)** described that the trunk of the radial artery is not crossed by any muscle but the brachio radialis lateral and overlaps it and the flexor carpi radialis is medial in distal two thirds. Then the radial artery gains the dorsum of the wrist by passing below the styloid process and deep to abductor pollicis longus.

Then it enters the palm between two heads of first dorsal interosseous muscle, passing medially to complete deep palmar arch by joining with the deep branch of ulnar artery.

In the present study in 48 specimens (96%) the radial artery descends along the lateral side of the forearm. Proximally it is overlapped anteriorly by the belly of brachio radialis and after that covered only by skin, superficial and

deep faciae up to wrist. Then it curves dorsally deep to the tendons of anatomical snuff box and enters palm in between 2 heads of first dorsal interosseous muscle. Then the radial artery passes medially deep to oblique head of adductor pollicis and completed the deep palmar arch by joining with the deep branch of ulnar artery.

Hence this study coincides with Henry Gray, George A Piersol, Parsons Schaeffler, J.D. Boyd et al, R.D Lockhart et al, Sir John Bruce, Hamilton, Kanagasuntheram and Basmajian.

**2. Course of the radial artery**

**Johnston (1921)** quoted that the radial artery is comparatively superficial throughout its whole course. He had not given any statistical data.

**JCB Grant (1957)** said that the radial artery may run a superficial course.

**Ernest Gardner, Donald J. Gray (1967)** also stated that occasionally the radial artery runs a very superficial course throughout the forearm.

**Rohan O' Rahilly (1978)** mentioned that occasionally the radial artery runs as very superficial course throughout the forearm. But statistical data was not given.

**Michael Sachs (1987)** described that in 5 out of 570 soldiers, the radial artery was subcutaneous in position which coursed superficial to the anatomical snuff box and crossed superficial to the tendon of extensor pollicis longus muscle.

**M.Rodriguez – Niedenfuhr (2003)** reported that the superficial radial artery is coursing over the tendons defining the snuff box and it was present in 0.4% of adult upper limbs.

In the present study in 2 specimens (4%) the course of the radial artery was superficial from the middle of the forearm and over the anatomical snuff box and differs from Johnston, Ernest Gardner, Donald J. Gray, Rohan O' Rahilly who mentioned that the radial artery runs a very superficial course throughout the forearm (Table – 12).

**Michael Sachs (1987)** and **M. Rodriguez – Niedenfuhr (2003)** stated that the radial artery coursed superficial to the anatomical snuff box but the incidence in the present study is higher (4%) than mentioned by Michael Sachs (0.9%) and Rodriguez M.Niedenfuhr (0.4%).

**3. Branches of radial artery**

**a) Radial recurrent branch**

**C. Latimer Callander, Dean Lewis (1939)** mentioned that the radial recurrent artery arises from the radial artery near its origin from brachial artery.

**George A. Piersol (1930)** said that the radial recurrent branch arises from the lateral part of the radial artery shortly below its origin.

**J.E.Frazer (1937)** stated that the radial artery gives the radial recurrent branch close to its commencement.

**Russell T. Wood Burne (1957), Sir John Bruce, Robert Walmsley, James A. Ross (1964), Barry J. Anson, Chester B. McVay (1971)** also quoted that

the origin of the radial recurrent artery was close to the origin of the radial artery. In the present study in 88% of specimens, the radial recurrent artery arose from the radial artery close to its origin. Hence this study coincides with the study of the above mentioned authors.

**J.Parsons Schaeffer (1942)** described about the radial recurrent artery which usually arises from the lateral side of the radial artery just beyond its origin from the brachial artery.

**Keith. L. Moore (1980)** stated that the radial recurrent branch arises from the lateral side of the radial artery just distal to its origin. In the present study in 6% of specimens the origin of radial recurrent artery was 2.5 – 3cm distal to the origin of the radial artery which coincides with the study of J. Parsons Schaeffer and Kieth L. Moore.

**J.C.B. Grant, James Couper Brash (1957)** said that the radial recurrent artery may spring from the brachial or ulnar arteries. In the present study, radial recurrent artery arose from the brachial artery in 6% of cases. But in none of the case in this study the radial recurrent branch was found to arise from ulnar artery.

**b. Superficial palmar branch**

**Prof. Johnston (1921)** described that the superficial palmar branch of the radial artery frequently completes the superficial palmar arch.

**J.E.Frazer (1937) Emmanuel B.Kaplan (1953)** said that the superficial arterial arch is formed by anastomosis with superficial palmar branch of the radial artery.

**J.D. Boyd et al (1956)** mentioned that on the anterior aspect, the radial artery gives superficial palmar branch which anastomoses with the superficial division of the ulnar artery to form superficial palmar arch.

**Sir John Bruce, Robert Walmsley, James A. Ross (1964)** stated that sometimes the superficial palmar branch of the radial artery completes the superficial palmar arch.

**J.Parson Schaeffer (1942)** quoted that the superficial volar branch courses forward over the short muscles of the ball of the thumb and anastomoses with the superficial branch of the ulnar artery to complete the superficial volar arch.

**Russel T.Wood burne (1957)** said that the superficial palmar branch passes over or through the muscles forming the eminence of the thumb.

**Sir Solly Zuckerman (1961)** also mentioned that the superficial palmar arch is completed laterally by the superficial palmar branch of the radial artery which passes over the thenar muscles. In the present study in 52% of cases the superficial palmar branch passes over the thenar muscles and completed the superficial palmar arch formed by the ulnar artery. Hence this finding coincides with that of Parson Schaeffer, Russel T. Wood burne, Sir Solly Zuckerman.

**Henry Gray (1858**) said that the superficial palmar artery passes through and occasionally over the thenar muscles which it supplies, sometimes anastomose with the end of ulnar artery to complete the superficial palmar arch.

**Thomas Walmsley (1934**) described about the superficial palmar artery which arises near the root of the thumb and runs distally first superficial to and then among its short muscles and it often completes the superficial palmar arch.

**C. Latimer Callander, Dean Lewis (1939)** stated that the superficial volar artery runs through the short muscles of the thumb to meet the ulnar artery and complete the superficial palmar arch.

**G.J.Romanes (1964)** described that the superficial palmar branch pierces the muscles of thenar eminence and ends or by joining the ulnar artery to complete the superficial palmar arch.

**R.D. Lockhart et al (1959), Sir John Bruce, Robert Walmsley, James A. Ross (1964)** said that the superficial palmar branch may pass through or over the thenar muscles and complete the superficial palmar arch.

In 42% of cases in the present study the superficial palmar branch of the radial artery passes through the substance of thenar muscles and completes the superficial palmar arch as mentioned by Henry Gray, Thomas Walmsley and C. Latimer Callander, Dean Lewis and G.J. Romanes.

**George A. Piersol (1930)** mentioned about the superficial palmar branch that frequently takes no part in the formation of the superficial volar arch and may

terminate in the muscles of the thenar eminence and it was not involved in the completion of the superficial palmar arch.

**G.J.Romanes (1964)** mentioned that the superficial palmar branch usually pierce the muscles of the thenar eminence and ends either in their substance or by joining the ulnar artery to complete the superficial palmar arch.

In the present study in 6% of cases the superficial palmar branch was very slender and ends by supplying the thenar muscles which was similar to the findings mentioned by George. A. Piersol and G.J.Romanes.

**C. Arteria princeps pollicis**

**George A Piersol (1930)** said that the arteria princeps pollicis arises from the radial artery just as it emerges from between the two heads of 1$^{st}$ dorsal interossei muscle.

**Thomas Walmsley (1934), R.D. Lockhart et al (1959**) described that the arteria princeps pollicis arises from the radial artery after it enters into the palm between the two heads of first dorsal interossei muscle.

**Sir Solly Zuckerman (1961)** mentioned that the arteria princeps pollicis is the branch of the main terminal part of the radial artery, when it returns to the deep aspect of the palm.

**Richard S. Snell (1973), Kanagasuntheram, Sivanandha Singham, Krishnamurti (1987)** also mentioned that the origin of the arteria princeps pollicis is from the radial artery after it entered the palm in between the 2 heads of first dorsal interossei muscle.

In the present study in 90% of cases the arteria princeps pillicis arose from the radial artery after it entered into the palm which coincides with the statement of the above said authors.

**Thomas Walmsley (1934)** stated that the arteria princeps pollicis sometimes arises from the radial artery on the back of the hand.

**Russel T.Wood Burne (1957)** mentioned that the arteria princeps pollicis arises from the radial artery on the dorsal aspect of hand.

In the present study in 4% of cases the arteria princeps pollicis arose from the radial artery in the dorsal side, which coincides with the study of Thomas Walmsley and Russel T.Wood Burne.

**J.E. Frazer (1937)** quoted that the arteria princeps pollicis may arise from the superficial palmar arch, from median artery or from the superficial palmar branch of radial artery.

**Henry Gray (1958)** mentioned that the arteria princeps pollicis arises from the superficial palmar arch and it is the usual nutrient artery to the first metacarpal bone.

In the present study in 4% of cases the arteria princeps pollicis arose from the superficial palmar arch which coincides with the findings of Henry Gray and ; J.E.Frazer.

As J.E.Frazer mentioned in 2% of cases in the present study, the arteria princeps pollicis arose from the superficial palmar branch of the radial artery over the thenar eminence. But in none of the cases the arteria princeps pollicis

was found to arise from the median artery in the present study as quoted by J.E.Frazer.

**George A. Piersol (1930)** stated that the arteria princeps pollicis arises from the deep palmar arch. **J.E. Frazer (1937)** stated that the arteria princeps pollicis arises from the deep palmar arch. But in the present study in none of the cases the arteria princeps pollicis was found to arise from deep palmar arch.

**J.C.B. Grant, James Couper Brash (1957)** mentioned that the arteria princeps pollicis may be absent and their places being taken by the branches of superficial palmar arch. But in the present study in all 50 cases, the arteria princeps pollicis was present. So my study differs from the finding of J.C.B. Grant, James Couper Brash.

**G.J.Romanes (1964), Ernest Gardner et al (1967)** said that the arteria princeps pollicis completes the superficial palmar arch which was not found in the present study.

**d. Arteria radialis indicis:**

**Thomas Walmsley (1934)** stated that the arteria radialis indicis arises from the radial artery after it entered into the palm and it may give a branch which completes the superficial palmar arch.

**R.D.Lockhart et al (1959), Sir, Solly Zuckerman (1961)** also mentioned that the arteria radialis indicis arises from the radial artery after it entered into the palm.

**Richard S. Snell (1973)** descsribed that on entering the palm, the radial artery gives off the arteria radialis indicis artery. In the present study, in 94% of cases, the arteria radialis indicis arose from the radial artery in the palmar side which was also mentioned by Thomas Walmsley, R.D.Lockhart et al, Sir Solly Zuckerman and Richard S.Snell.

**Henry Gray (1858)** said that the arteria radialis indicis arises from the superficial palmar arch.

**J.E.Frazer (1937)** mentioned that the arteria radialis indicis may be derived from the superficial palmar arch or from the enlarged median artery or from the superficial palmar branch of the radial artery.

**Weathersby (1954)** stated that in 13% of cases he found that the arteria radialis indicis arose from the superficial palmar arch

In the present study in 2% of cases, the arteria radialis indicis arose from the superficial palmar branch of the radial artery in the palm which was mentioned by J.E.Frazer but in none of the cases in the present study the arteria radialis indicis was found to arise from the median artery. In 4% of cases in the present study the arteria radialis indicis arose from the superficial palmar arch which coincides with the study of Henry Gray, Weathersby and J.E.Frazer. But the incidence in the present study is (4%) which is much lesser than the incidence given by Weathersby which was 13%.

**e. Palmar carpal branch**

**Henry Gray (1858)** described the palmar carpal branch as a slender branch.

**George A.Piersol (1930)** said that the volar radial carpal branch of the radial artery was very slender and anastomose with branches from volar ulnar carpal branch of the ulnar artery.

**Thomas Walmsley (1934)** described that the anterior carpal branch is a slender branch arising from the radial artery anteriorly.

**J.E.Frazer (1937)** and **J.Parsons Schaeffer (1942)** also mentioned that the palmar carpal radial branch of the radial artery as a slender branch arising from the radial artery arteriorly near the distal border of pronator quadratus.

In the present study, in all 50 specimens (100%) the palmar carpal branch was a slender branch from the radial artery in the anterior aspect thereby similar to the findings mentioned by the above authors.

**f. First dorsal metacarpal artery**

**Henry Gray (1858), George A.Piersol (1930) and J.Parsons Schaeffer (1942)** described that the first dorsal metacarpal artery was the direct smaller branch of the radial artery.

**Thomas Walmsley (1934)** quoted that the dorsal metacarpal artery arose directly from the posterior carpal arch.

**J.E.Frazer (1937)** mentioned that the first dorsal metacarpal artery arose directly from the radial or from the dorsal carpal arch.

In the present study, in all 50 cases (100%) the first dorsal metacarpal artery arose as a direct smaller branch from the radial artery which coincides with the statement of Henry Gray, George A. Piersol and Parsons Schaeffer. The present study differs from that of Thomas Walmsley and J.E.Frazer, because the origin of the first dorsal metacarpal artery from dorsal carpal arch was not observed in any of the specimens in the present study.

**g. Dorsal carpal branch**

**Henry Gray and George A. Piersol (1930)** described the dorsal carpal branch as a very slender one.

**Thomas Walmsley (1934)** quoted that the posterior carpal branch was a slender branch arising from the radial artery dorsally.

**J.E.Frazer (1937), J.Parsons Schaeffer (1942)** also mentioned that the dorsal carpal branch of the radial artery was a slender branch arising on the dorsal side. In all 50 cases (100%) in the present study the dorsal carpal branch arose from the radial artery on the dorsal side and coincides with the findings of Henry Gray, George A.Piersol, Thomas Walmsley, J.E.Frazer and J.Parsons Schaeffer.

**h. Origin of interosseous artery from the radial artery**

**Henry Gray (1858)** quoted that the radial artery can give rise to the common interosseous artery.

**Bilodi AK, Sanikop MB (2004)** found that the common interosseous artery arising from the radial artery. In the present study, in 2% of cases the common

interosseous artery arose from the radial artery which coincides with the findings given by Henry Gray and Bilodi, Sanikop. Whereas in 2% of cases in the present study, the anterior interosseous artery arose from the radial artery and none of the authors mentioned this variation.

**4. Completion of Superficial palmar arch**

**Prof. Johnston (1921)** quoted that the superficial palmar branch of the radial artery frequently completes the superficial palmar arch.

**Beuntaro Adachi (1928)** described that the “radio-ulnar” type of superficial palmar arch in which the superficial palmar branch completes the superficial palmar arch was seen in 32% of caes.

**J.E.Frazer (1937)** said that the superficial palmar arch was completed by superficial palmar branch of the radial artery.

**C. Latimer callander, Dean Lewis (1939)** mentioned that the superficial volar artery completes the superficial palmar arch.

**J.Parsons Schaeffer (1942), J.D.Boyd et al (1956)** also mentioned that the superficial palmar branch of the radial artery completes the superficial palmar arch.

**Emanuel B.Kaplan (1953)** stated that the superficial radial palmar artery participates in the formation of the superficial palmar arch which was encountered in about 30% of the cases.

**Lawrence J. McCormack, Cauldwell E.W. and Anson B.J. (1953)** stated that in 80 of 750 specimens, only in 15 specimens (18.8%) they found that the volar arch was formed in the usual manner by a branch of the radial artery.

**Weathersby (1954)** said that the superficial palmar arch was completed by the superficial palmar branch of the radial artery in about 35% of hands.

**R.D. Lockhart et al (1959)** said that the superficial palmar branch may complete the superficial palmar arch.

**Coleman S.S and Anson B.J. (1961)** described that the superficial palmar arch was completed by a superficial branch of the radial artery in about 35% of hands.

**Sir John Bruce, Robert Walmsley, James A. Ross (1964), G.J. Romanes (1964)** mentioned that the superficial palmar arch was completed by the superficial palmar branch of the radial artery.

**Erlandson et al (1981)** described that among 80% of complete palmar arch, the ulnar and radial artery origin was 36%.

**Brian F.Buxton (1998)** described that the superficial palmar branch of the radial artery completing the superficial palmar was uncommon seen in 12.5% of cases. In the present study in 94% of cases the superficial palmar branch of the radial artery completed the superficial palmar arch which was also mentioned by Prof.Johnston, J.E.Frazer, Latimer Callander, J.Parsons Schaeffer, J.D.Boyd, R.D.Lockhart et al, Sir John Bruce, and G.J.Romanes, But they had not given any statistical data regarding this (Table– 13). But the

incidence in this present study (94%) is higher than the incidence given by Beuntaro Adachi (32%), Emanuel B.Kaplan (30%), Weathersby (35%), Coleman S.S. and Anson B.J.(35%), Erlandson et al (36%) and Lawrence J. McCormack (18%).

In the present study most common finding is the completion of superficial palmar arch by the superficial branch of radial artery (94%) which differs from the statement of Brian F.Buxton who described this as uncommon. Weathersby quoted that in 12% of cases there was no connection of the arch to branches of the radial artery on the radial side.

**Coleman S.S. and Anson B.J. (1961)** listed about 21.5% of incomplete superficial palmar arches.

**Robert B.Rutherford (2005)** stated that incomplete superficial palmar arch was seen in 20% of cases. In the present study, in 4% of cases the superficial palmar arch was incomplete, where the superficial palmar branch of radial artery which is very thin and ends by supplying thenar muscles and the ulnar artery terminated as incomplete arch. But the incidence given by Weathersby (12%) Coleman S.S. (21.5%) and Robert B. Rutherford is higher than the present study. In the present study in 2% of cases, the superficial palmar arch was completed by the median artery.

**Thomas Walmsley (1934), J.E.Frazer (1937) Sir Solly Zuckerman (1961) and G.J.Romanes (1964)** described that the superficial palmar arch was completed by branches from the arteria radialis indicis and arteria princeps

pollicis or directly by arteria radialis indicis or the arteria princeps pollicis. But in the present study in none of the cases, the superficial palmar arch was completed by the above mentioned branches. So the present study differs from the work of the above said authors.

**5. Formation of deep palmar arch**

**Henry Gray (1858)** described that the deep palmar arch is formed by anastomosis of the end of the radial with the deep branch of the ulnar artery.

**Prof.Johnston (1921)** quoted that the deep palmar arch represents the direct continuation of the radial artery into the palm, the arch being completed on the medial side by union with the deep branch of the ulnar artery.

**George A.Piersol (1930)** mentioned that the radial artery terminates opposit the proximal part of the fourth metacarpal interspace by anastomosing with deep volar branch of the ulnar artery forming deep volar arch.

**Thomas Walmsley (1934)** stated that in the palm, the radial artery passes across the palm as deep palmar arch which is completed on the medial side by anastomosis with the deep branch of the ulnar artery.

**J.D.Boyd et al (1956), G.J.Romanes (1964)** said that in the palm the radial artery ends by anastomosing with the deep division of the ulnar artery to form deep palmar arch.

**John V.Basmajian, Charles E. Slonecker (1989)** mentioned that the radial artery continuation in the palm is completed by the deep branch of the ulnar artery and forms deep palmar arch.

**Mezzogiorno et al (1994)** found from their study of 60 vascular casts of upper extremity that the deep palmar arch was a complete arch formed by the radial artery and its continuation to a deep branch of the ulnar artery. There were four anatomic patterns identified.

1. Radio- ulnar (66.67%)
2. Radial anastomotic (21.67%)
3. Radial (8.33%)
4. Ulnar (3.33%)

**Brian F.Buxton (1998)** found in the deep palmar arch, continuity exists between the deep palmar branches of radial and ulnar arteries was found in 87.5% of hands.

**Rohart B. Rutherford (2005)** quoted that the deep volar arch was formed primarily by the radial artery anastomose with the deep volar ramus of the ulnar artery and this complete deep volar arch present in 97% of cases.

In the present study in 96% of cases the deep palmar arch was formed by the terminal part of the radial artery which anastomose with the deep branch of the ulnar artery. So the present study coincides with Henry Gray, Prof.Johnston, George A. Piersol, Thomas Walmsley, J.D.Boyd et al, G.J.Romanes, John. V. Basmajian, Mezzogiorna et al, Brian F. Buxton and Rohart B. Rutherford. But the statistical data was not given for this findings by them except, Mezzogiorna and Brian F. Buxton and Rohart B. Rutherford. The incidence mentioned by Mezzogiorna (66.67%) and by Brian F.Buxton

(87.5%) were lesser than the incidence in the present study (96%). But similar to that of Rohart B.Rutherford (97%) (Table – 14).

**Coleman S.S. and Anson B.J. (1961)** reported a few instances in which the arch was incomplete.

**Rohart B. Rutherford (2005)** found complete deep palmar arch in 97% of cases and incomplete arches in 3% of cases.

In the present study in 96% of cases the deep palmar arch was complete, which was formed by the terminal part of radial artery and the deep palmar branch of ulnar artery which nearer to the incidence mentioned by Rohart B.Rutherford (97%).

In 4% of cases in the present study the terminal part of the radial artery ends by supplying the adductor pollicis muscle and the deep palmar arch was incomplete which almost coincides with the incidence given by Rohart B.Rutherford (3%)

**JCB Grant, James Couper Brash (1957)** mentioned that the deep palmar branch of the radial artery was much more rarely absent.

**Mezzogiorna et al (1994)** found rarely a complete absence of the deep palmar arch. But in the present study in none of the cases the deep palmar arch found to be absent.

**Emanuel B.Kaplan (1953)** said that the anterior interosseous artery may participate in the formation of deep palmar arch with the radial artery. But this finding was not observed in the present study.

## II. ADULT CADAVERIC ANGIOGRAPHIC STUDY

By injecting contrast solution (urograffin) in 2 disarticulated upper limbs, it was noted that, the radial artery was the smallest division of the brachial artery and appears to be more continuation with the parent trunk. The radial recurrent branch, few muscular branches, deep palmar arch were noted. No abnormalities detected.

## III. CLINICAL STUDY

In 2 clinical cases in the age group of 30 and 35 years, brachial angiogram and doppler study was observed. With the help of the angiogram and doppler study, it was found that the radial artery was the smaller of two divisions of brachial artery and it was more continuation with the parent trunk. Branches of radial artery such as the radial recurrent branch, superficial palmar branches and amount of blood flow were visualised which were normal.

## IV. HISTOLOGICAL STUDY

**Gianfederico Possati, Maio Gaudino (2000)** stated that the radial artery was reintroduced in coronary artery bypass surgery due to its favourable anatomical position, caliber and length. They have also mentioned that from a histological point of view the radial artery is a thick walled muscular artery, whose vascular wall is irrorated at least in part by vasa-vasorum. The abundant muscular component of the radial artery is the anatomical background of the hyperspastic attitude of the artery.

In present study, the histological study of radial artery shows tunica intima, internal elastic lamina and thick tunica media with abundant smooth muscular fibres with few elastic fibres. The external elastic lamina also clearly visualised and the tunica adventitia has connective tissue fibers with few vasa vasorum and resembles the findings mentioned by Gianfederico (fig – 58).

The microstructure of the coronary artery also shows the typical features of muscular artery where the tunica intima, internal elastic lamina, tunica media with abundant muscular fibres, and few elastic fibres are seen. The tunica adventitia is made up of connective tissue (fig – 59). There by microstructures of coronary artery very closely resembles that of the radial artery.

# *Conclusion*

# CONCLUSION

The present study included cadaveric dissection with clinical study and histological study. The results of the study are based on the routine dissection methods, radiological methods including doppler study. The branching pattern and the variation of the radial artery in the present study has contributed to our knowledge regarding the relationship, course and the variation of the branching pattern which is of considerable practical importance in the conduct of reparative surgery in the forearm and hand. The arterial variations of the upper limb have been implicated in different clinical situations.

In the present study variations regarding the level of origin and the branches of the radial artery, their contribution to superficial palmar arch and deep palmar arch are encountered. Careful scrutiny of the anti cubital area should be made preceeding simple veni puncture, there is a possibility of accidental intra arterial injections may lead to gangrene of fingers, hand and forearms (fig – 60, 61).

The superficial position of the arteries make them vulnerable to trauma and also make them more accessible to cannulation if needed such as for arterio venous fistula in chronic renal failure, diabetes mellitus for dialysis purpose.

The superficial radial artery has been encountered during elevation of the radial forearm flap. The existence of the superficial radial artery implies the absence of the normal radial pulse at the wrist level.

The absence of the ulnar artery was responsible for hand ischaemia after radial artery grafting for coronary bypass. Traditionally blocks in the heart are treated through angioplasty performed through the artery of the groin which sometimes result in complications like prolonged bed rest, bleeding, blood clots, damaged artery and so on.

Now in recent practices, cardio thoracic surgeons have introduced “Radial Artery Access” by which a pinhole access through the wrist as a day care procedure. Through a tiny puncture catheters and stents are guided through the artery to the blocks in the heart. No need for incision, stitches, big scars or long recovery.

So the present study of “Radial artery and its branching pattern and variations” will be more useful to the clincians especially vascular surgeons and plastic surgeons.

**“ The real purpose of an author is to trap his mind thinking for others”**

**- Somerset Maugham.**

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**FIG – 1 ORIGIN & COURSE OF RADIAL ARTERY IN THE CUBITAL FOSSA**

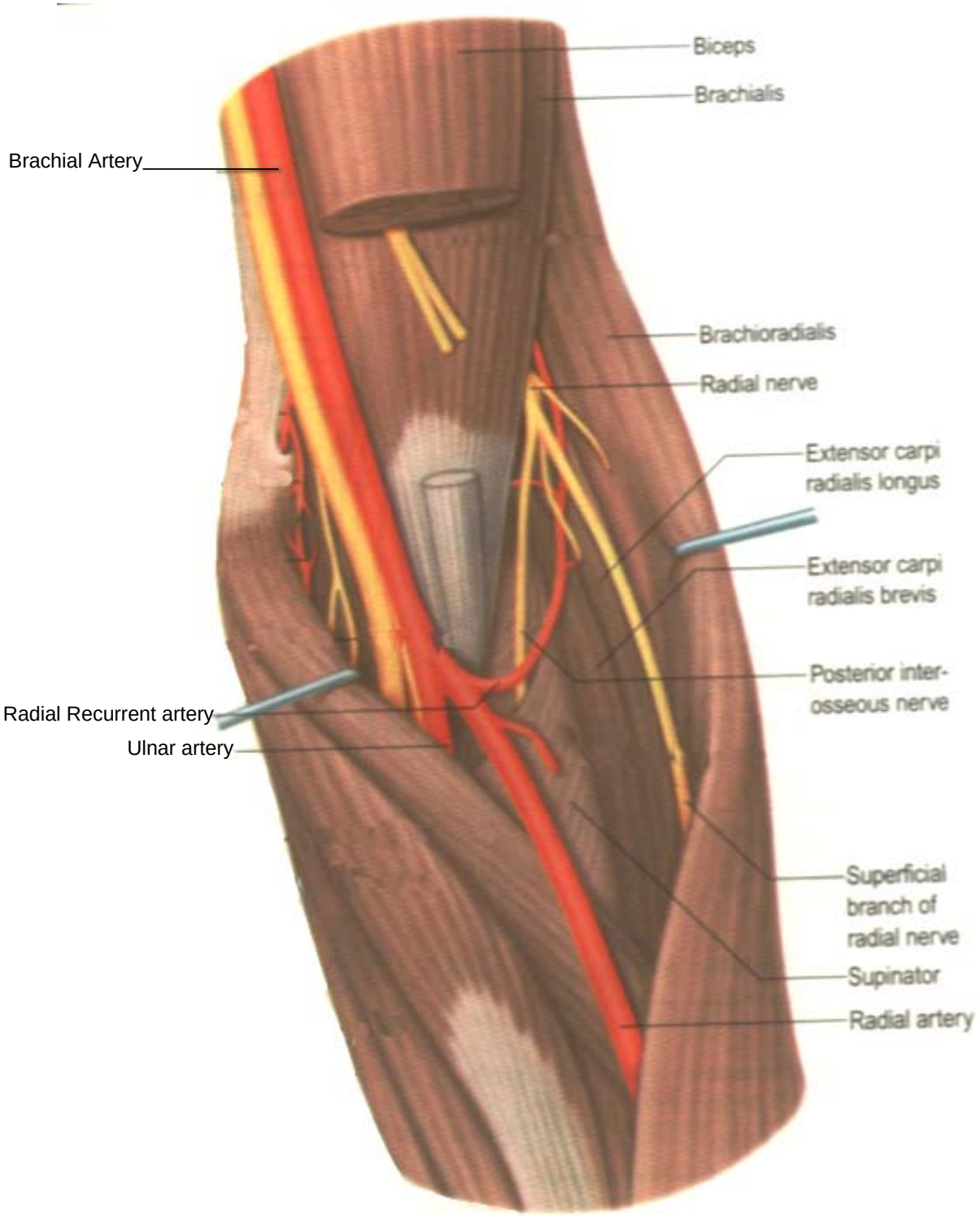


**FIG – 2 COURSE OF RADIAL ARTERY**

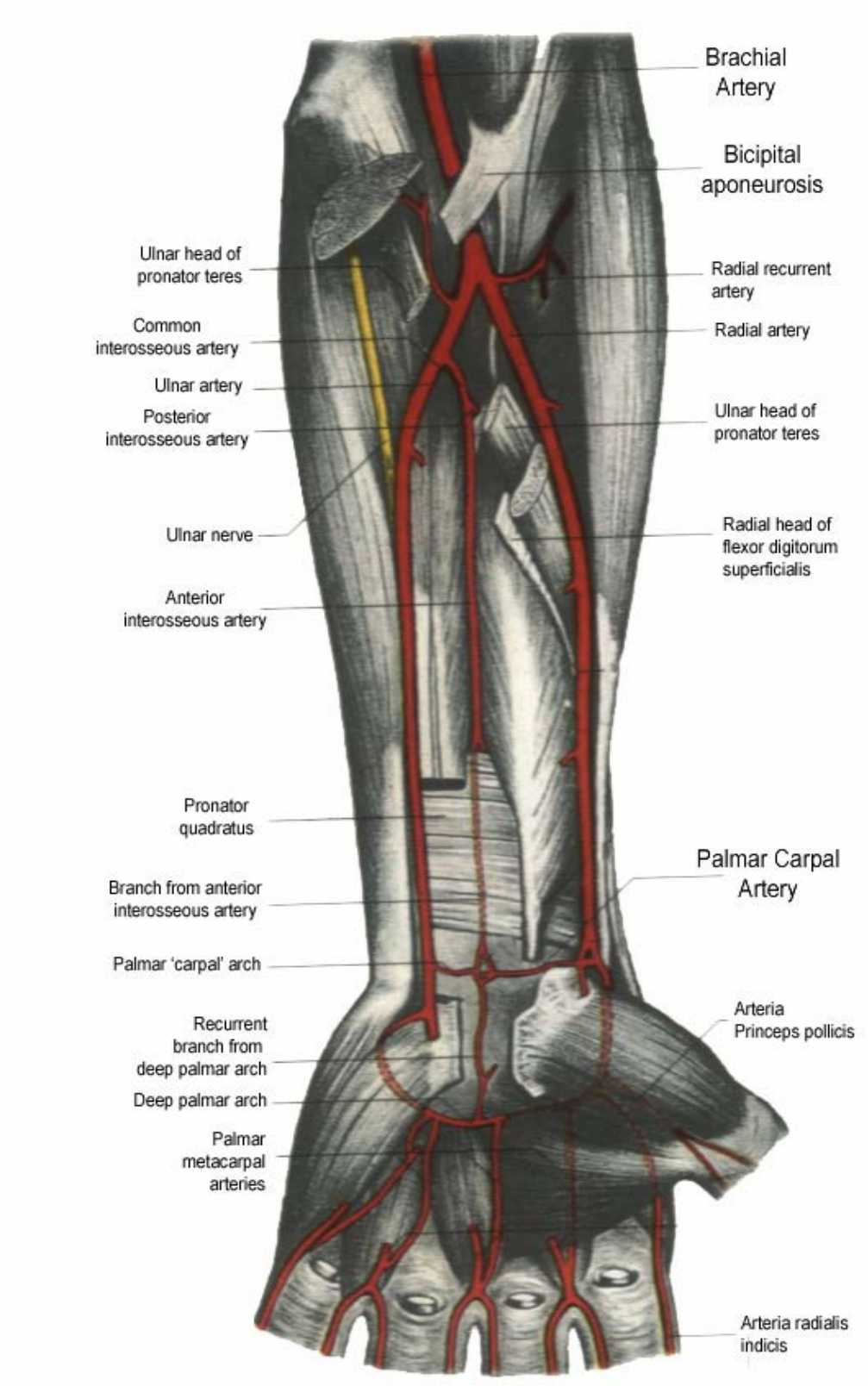
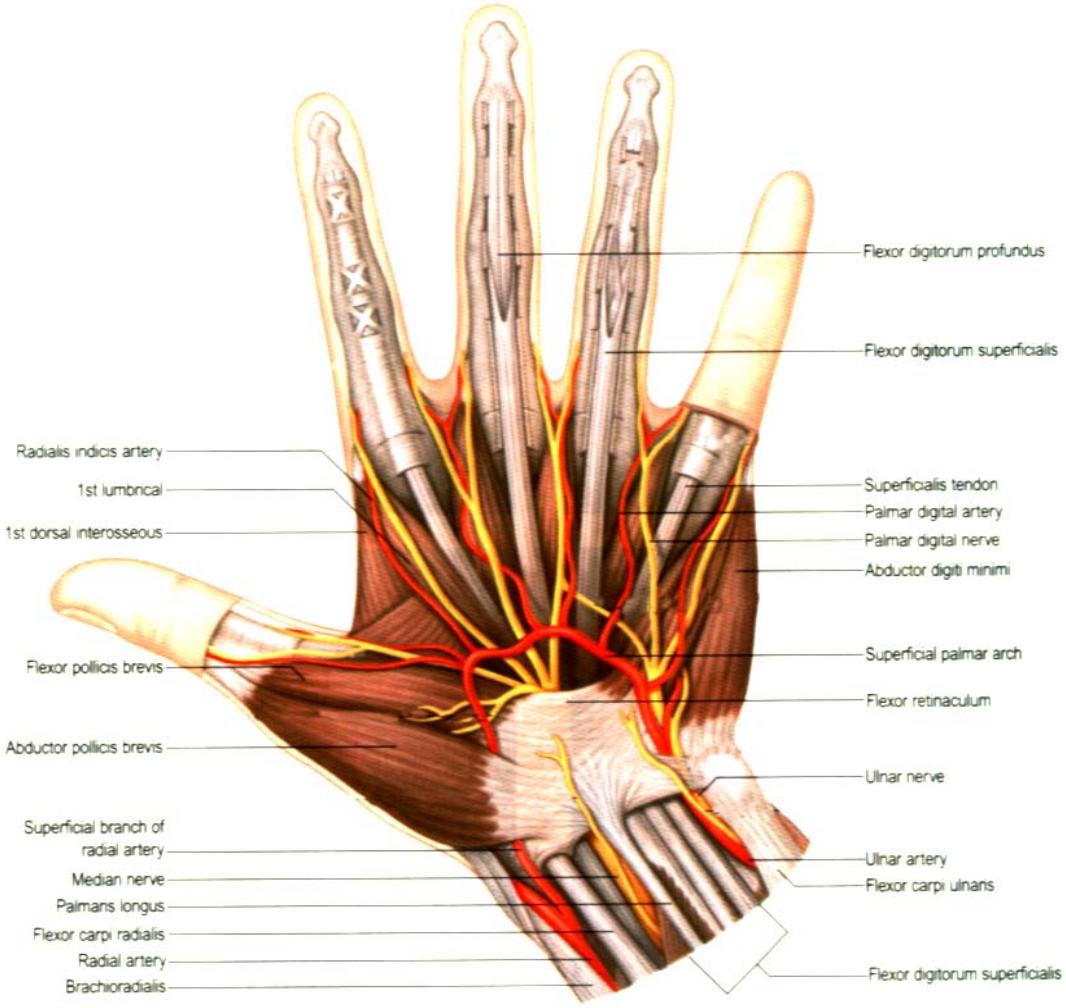


**FIG – 3 COURSE OF RADIAL ARTERY**

## FIG–4 SUPERFICIAL PALMAR ARCH



**FIG–4(a) TERMINATION OF THE RADIAL ARTERY IN THE PALM**

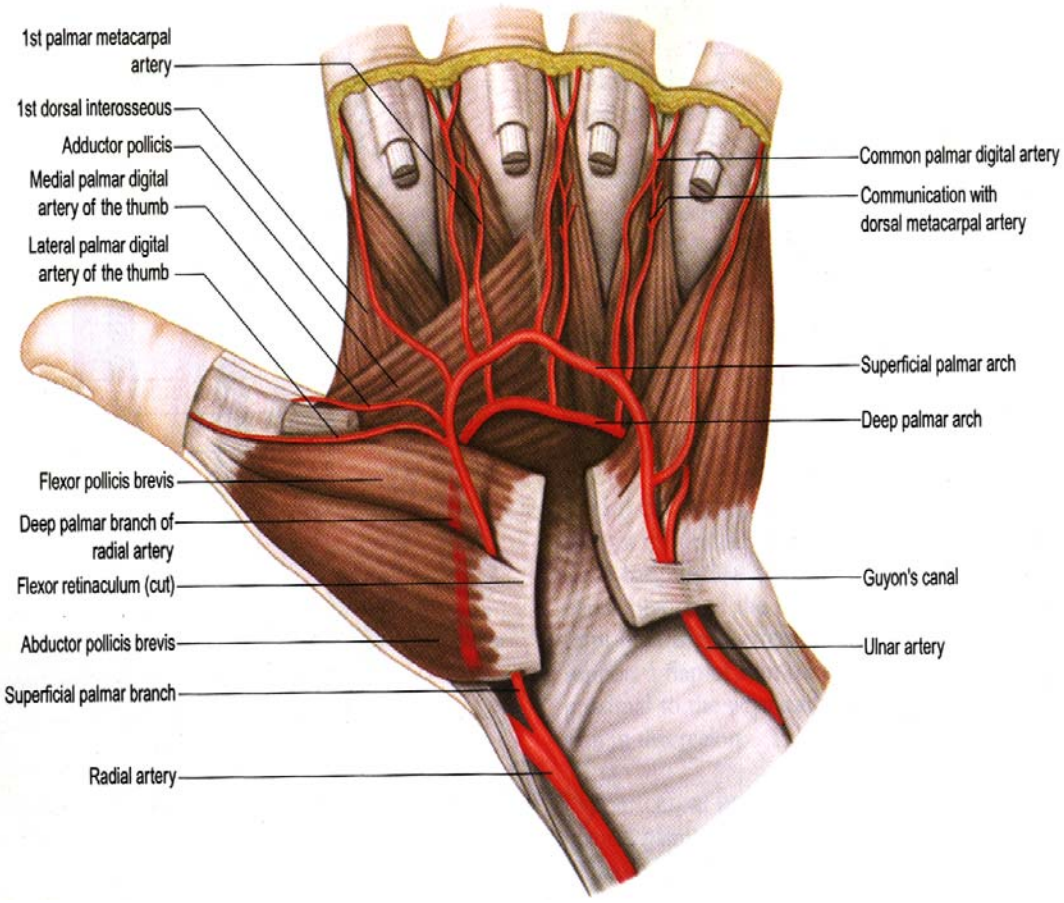


**FIG – 5 RADIAL ARTERY IN THE ANATOMICAL SNUFF BOX**

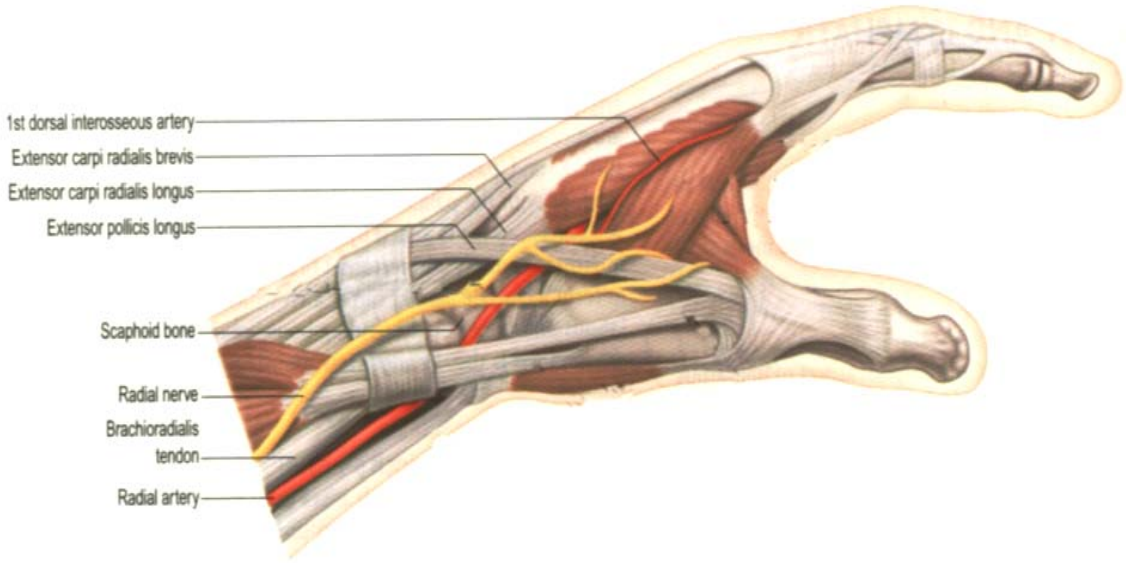


**FIG – 6 RADIAL ARTERY CONDUIT FOR CABG**

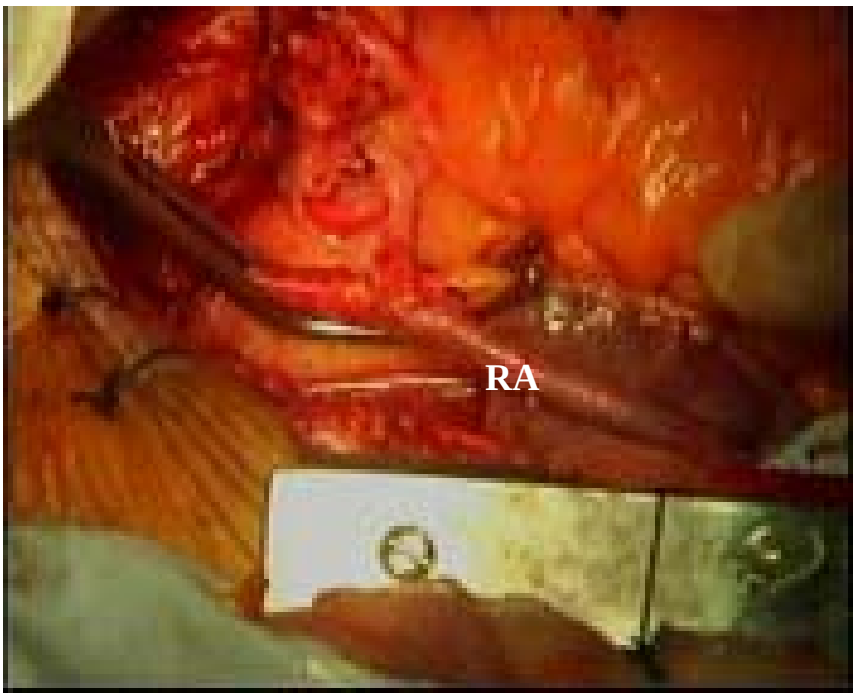
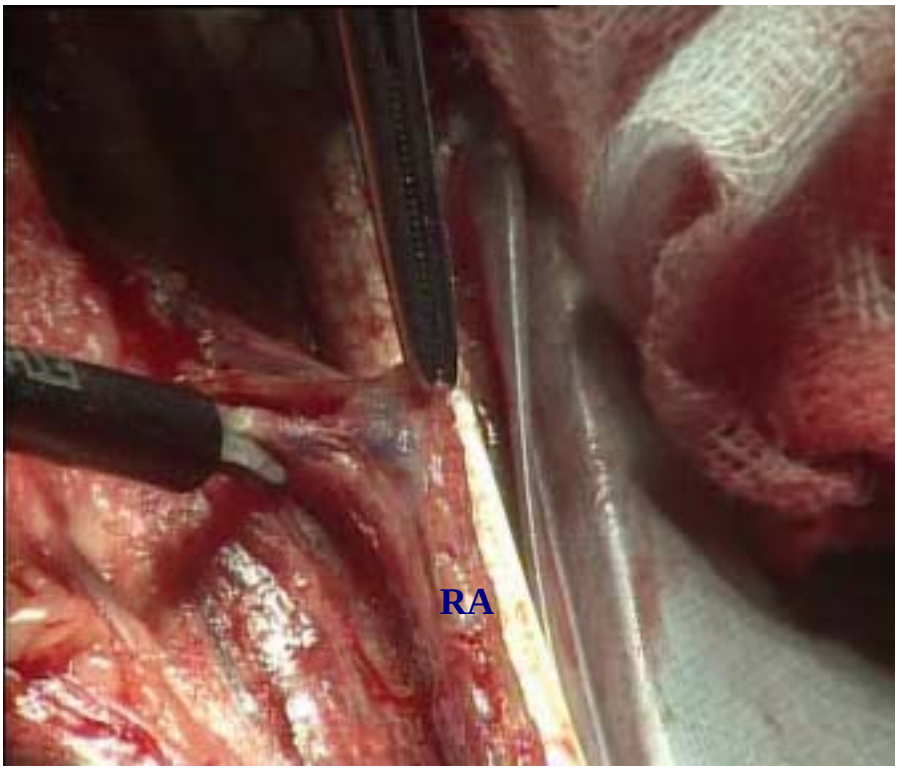
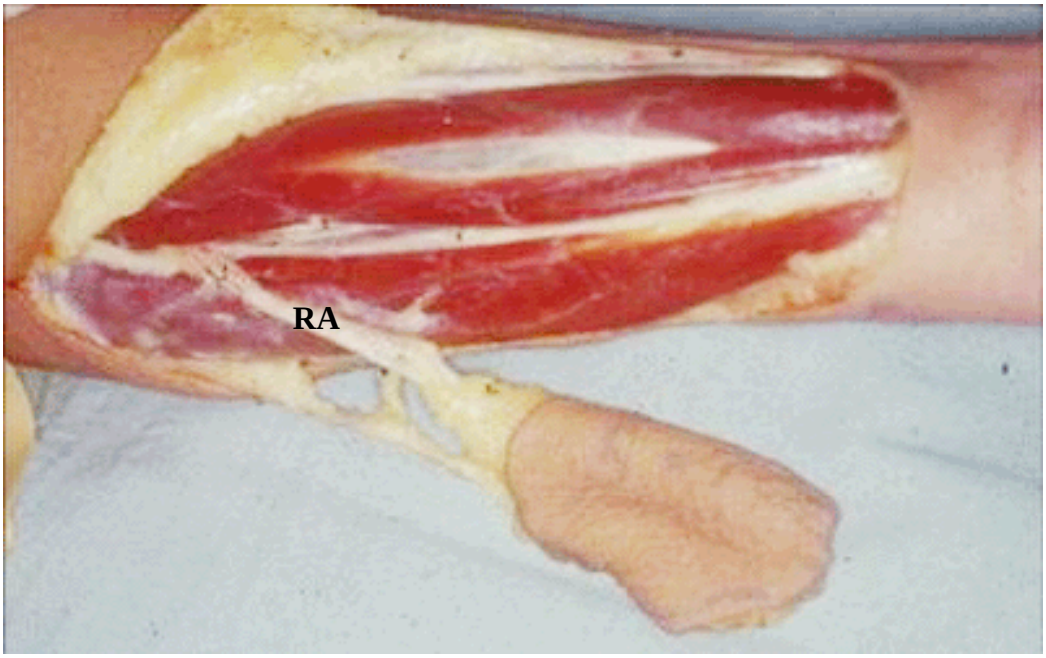



**FIG – 7 HARVESTING OF RADIAL ARTERY FOR CABG**




**RA – RADIAL ARTERY**
**CABG – CORONARY ARTERY BYPASS GRAFTING**

**FIG – 8 DISTALLY BASED FREE RADIAL FOREARM FLAP**




**RA – RADIAL ARTERY WITH FLAP**

**FIG – 9 SURFACE MARKING FOR FREE RADIAL FOREARM FLAP**

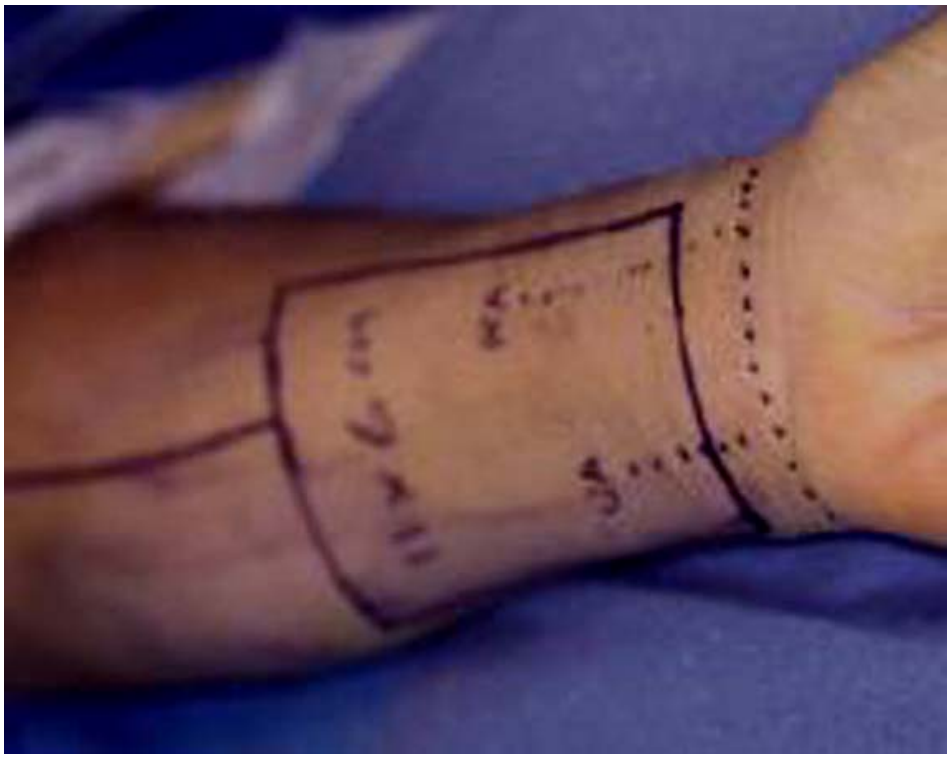


**FIG – 10 FREE RADIAL FOREARM FLAP**

**FIG – 11 FREE RADIAL FOREARM FLAP – WELL HEALED**

**FIG – 12 CABG RADIAL ARTERY TO AORTA – SCHEMATIC DIAGRAM**

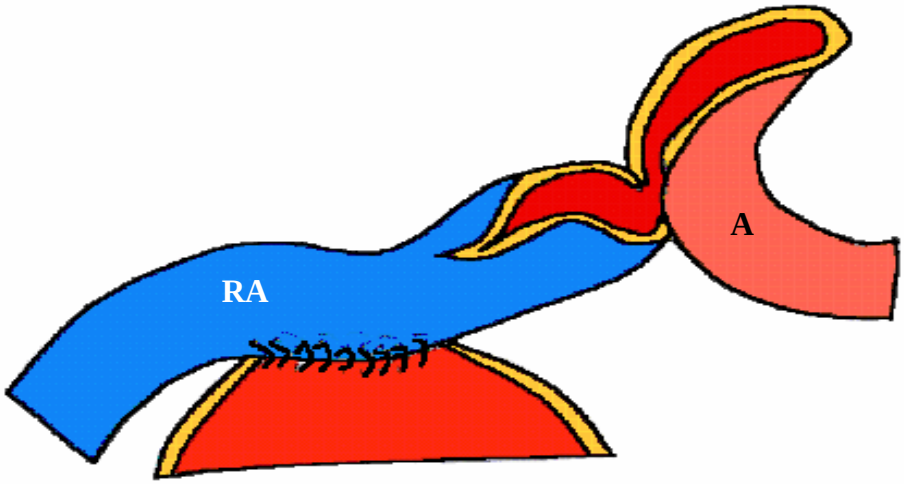
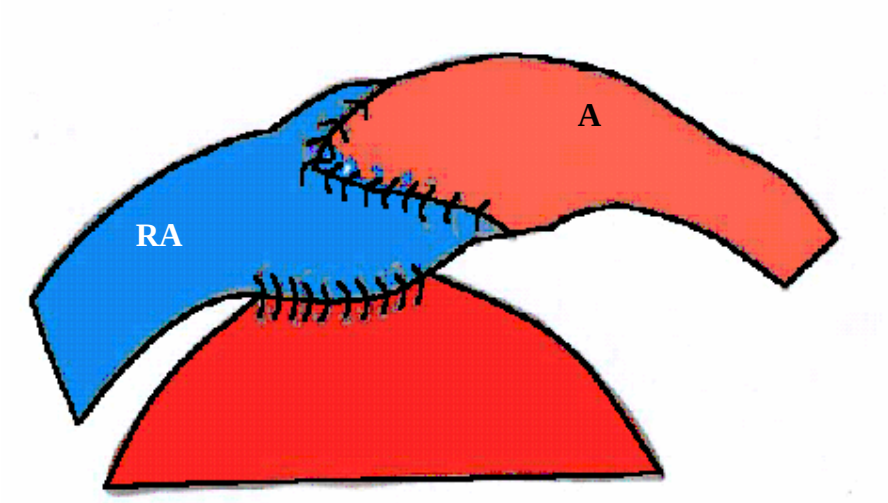



**FIG – 13 CABG RADIAL ARTERY TO AORTA – SCHEMATIC DIAGRAM**




**RA – RADIAL ARTERY**

**A – AORTA**

## FIG – 14 DEVELOPMENT OF RADIAL ARTERY

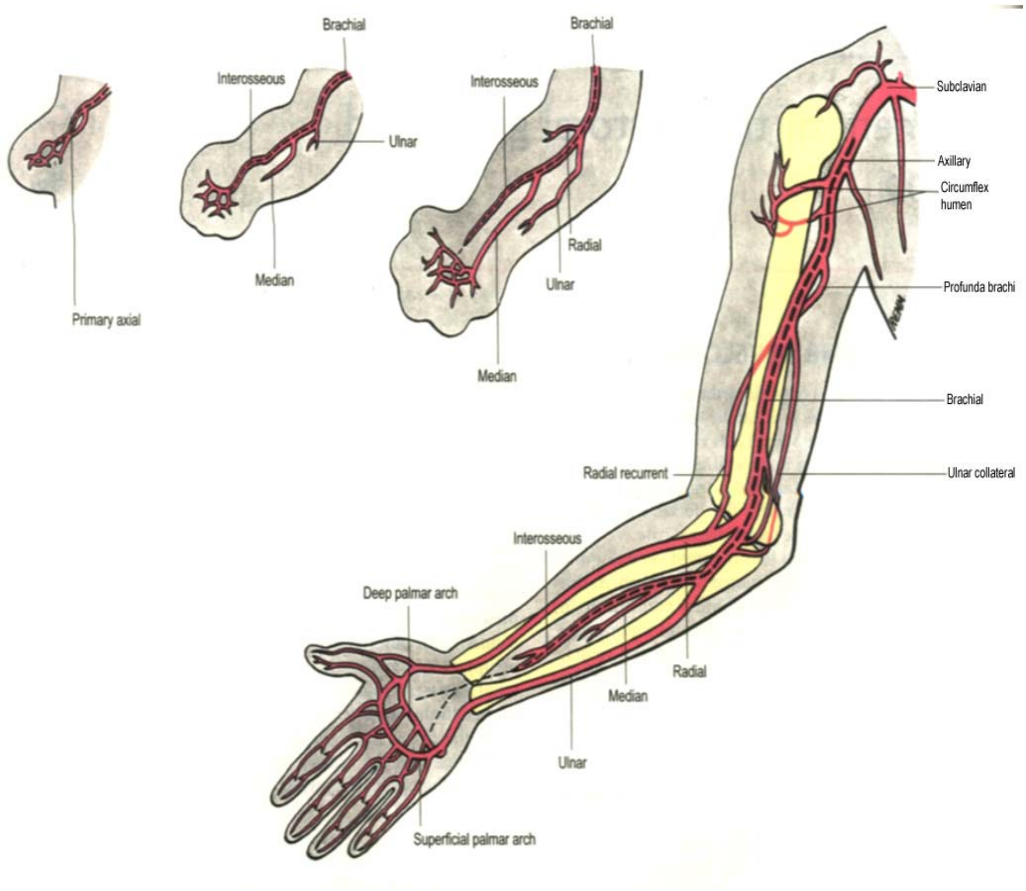
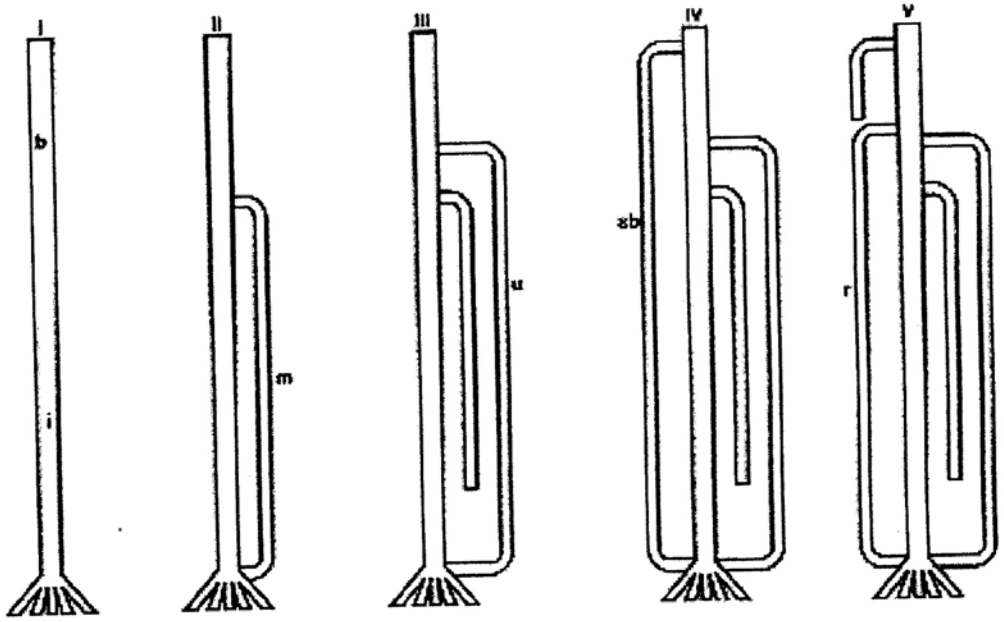


**FIG – 15 DEVELOPMENT OF RADIAL ARTERY – OLD THEORY**




b – brachial artery
i – interosseous artery
m – median artery
u – ulnar artery
sb – superficial brachial artery
r – radial artery

**FIG – 16 DEVELOPMENT OF RADIAL ARTERY – NEW THEORY**

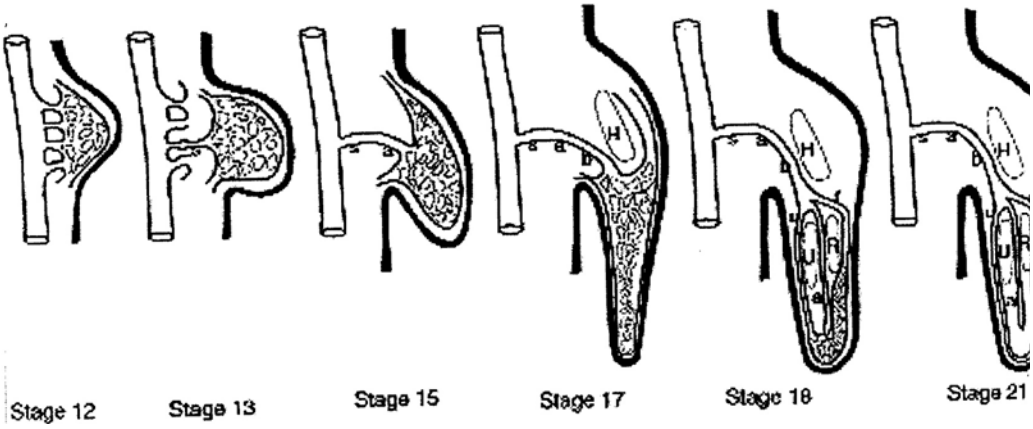


**FIG – 17 INCISION FOR EXPOSURE OF RADIAL ARTERY**

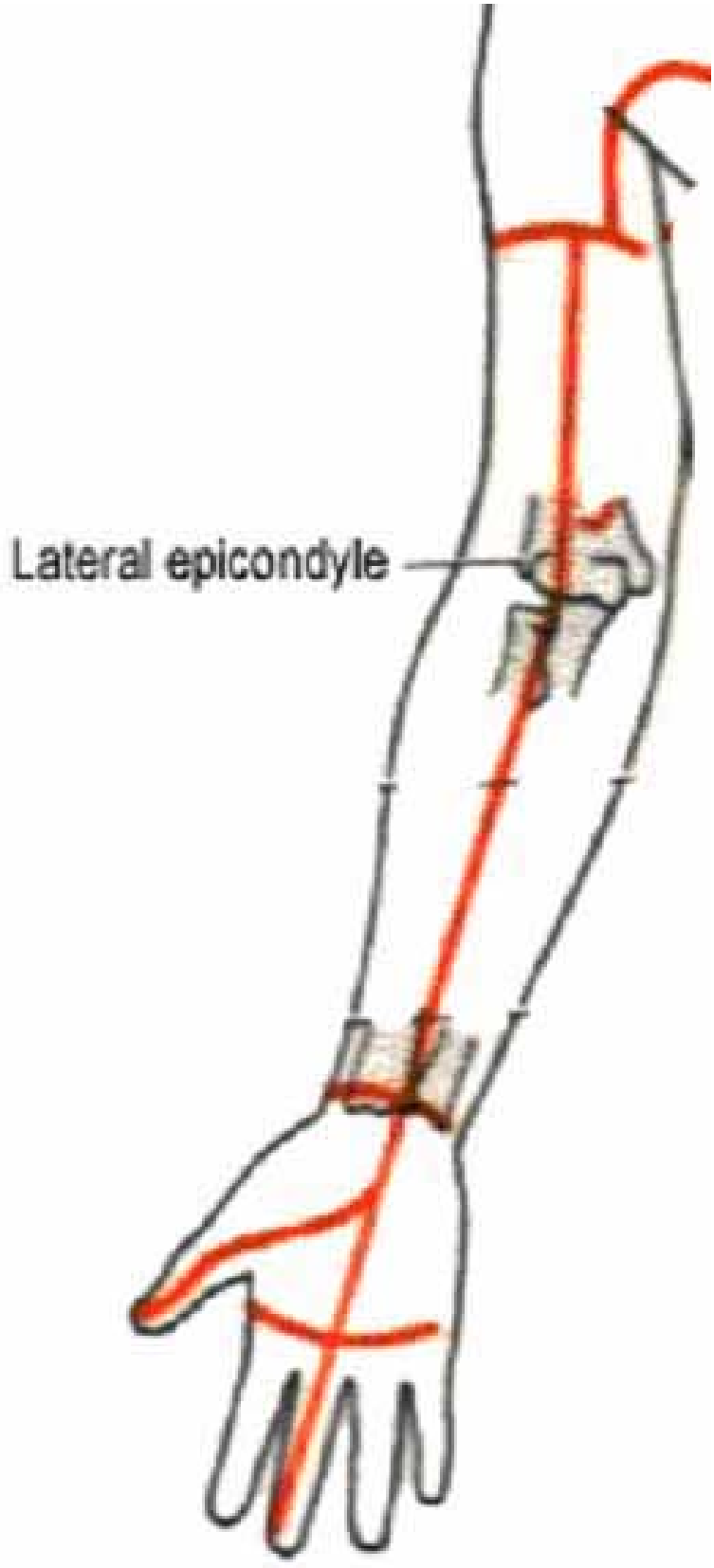
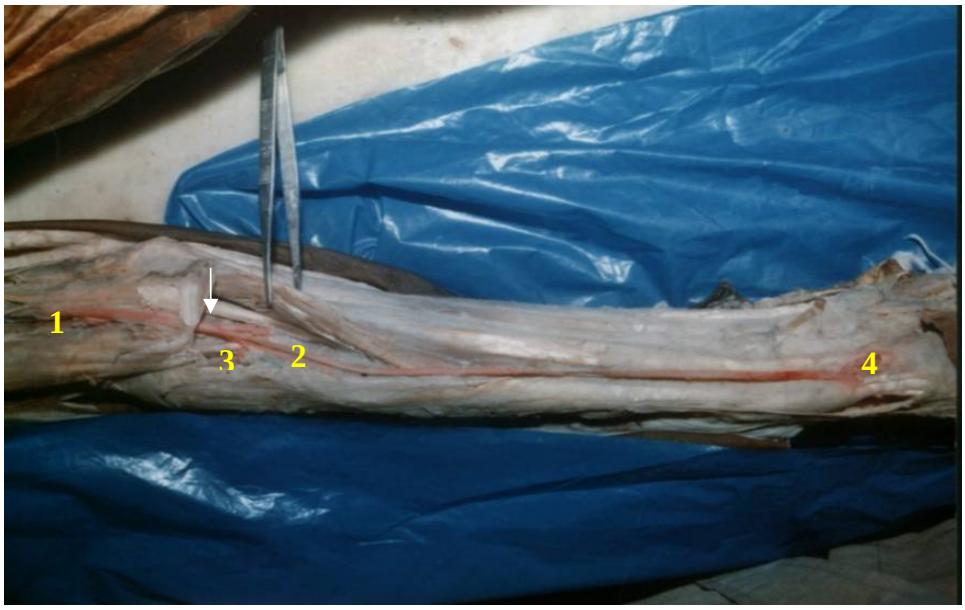


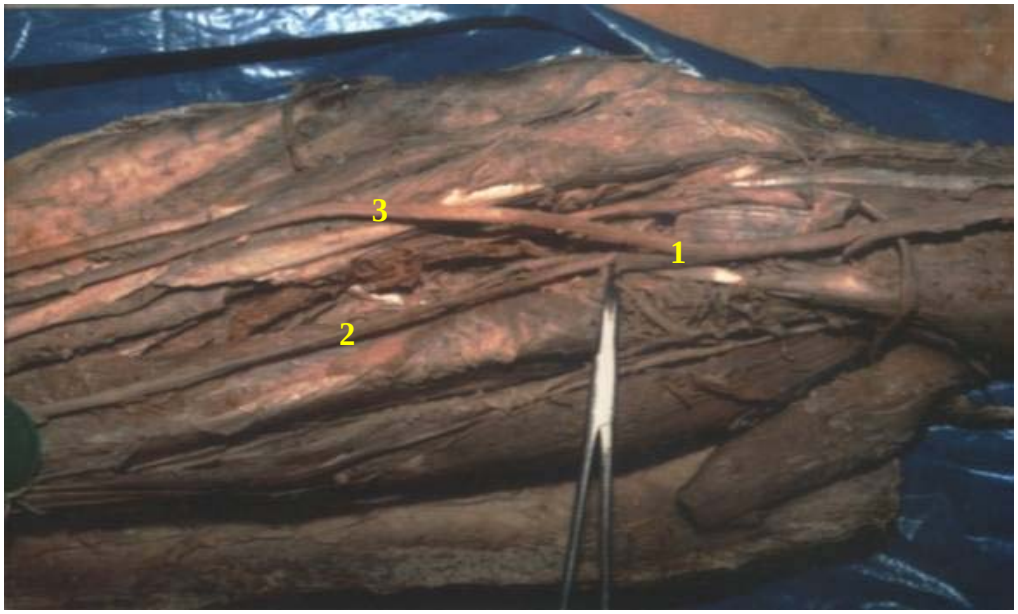
**FIG – 18 PLACING OF PROBE FOR RADIAL ARTERY DOPPLER STUDY**

**FIG – 19 ORIGIN OF RADIAL ARTERY AT THE NECK OF RADIUS**



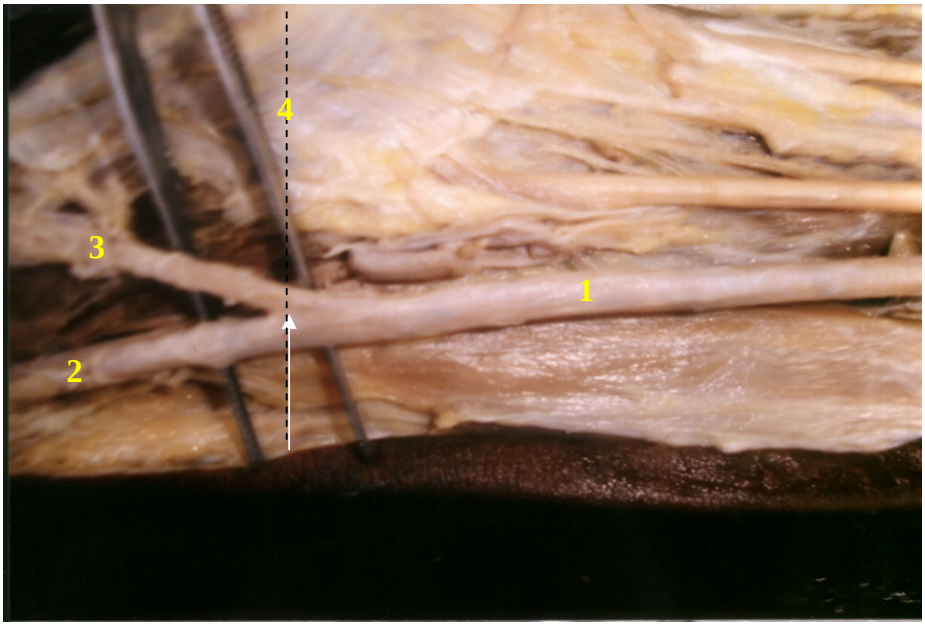

1. Brachial artery 2. Radial Artery
3. Radial Recurrent Artery 4 Superficial Palmar Branch

**Fig – 20 ORIGIN OF RADIAL ARTERY AT THE NECK OF RADIUS**



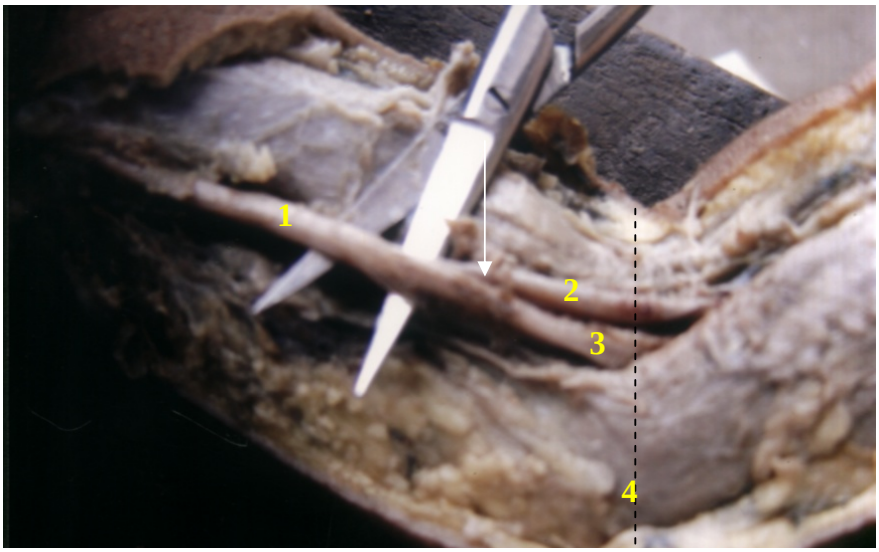

1. Point of Bifurcation 2. Radial Artery
3. Ulnar Artery

**FIG – 21 ORIGIN OF RADIAL ARTERY AT THE INTERCONDYLAR LINE**




1. Brachial Artery
2. Radial Artery
3. Ulnar Artery
4. Inter condylar line

**FIG – 22 ORIGIN OF RADIAL ARTERY ABOVE THE INTERCONDYLAR LINE**

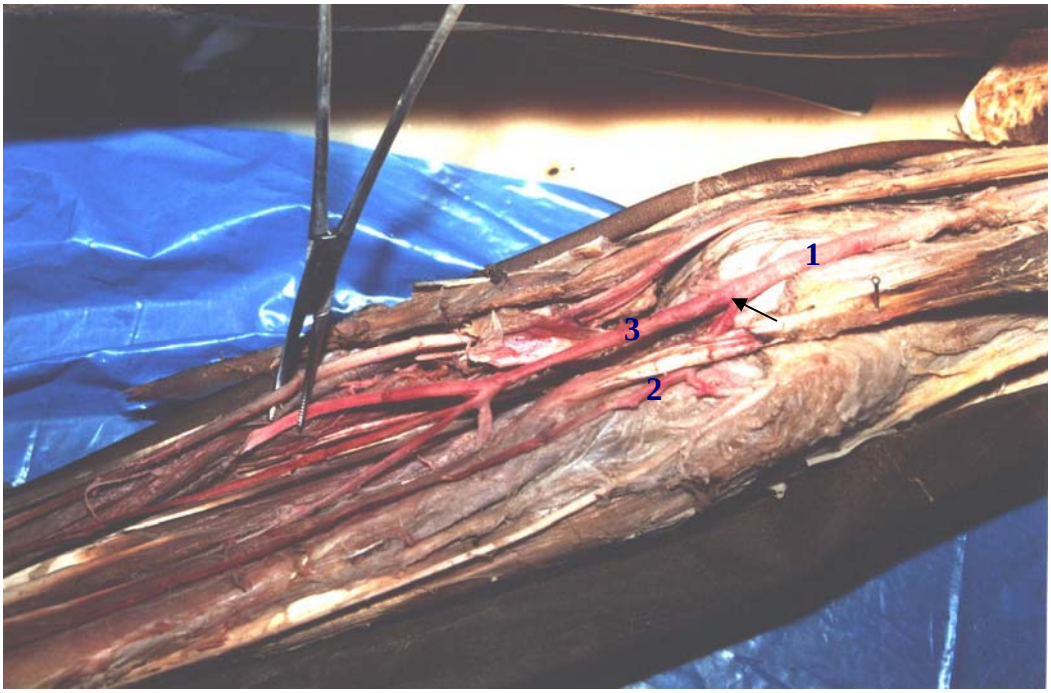



1. Brachial Artery
2. Radial Artery
3. Ulnar Artery
4. Inter condylar line

**FIG – 23 HIGH ORIGIN OF RADIAL ARTERY**


1. Brachial Artery 2. Radial Artery
3. Ulnar Artery

**FIG – 24 HIGH ORIGIN OF RADIAL ARTERY**

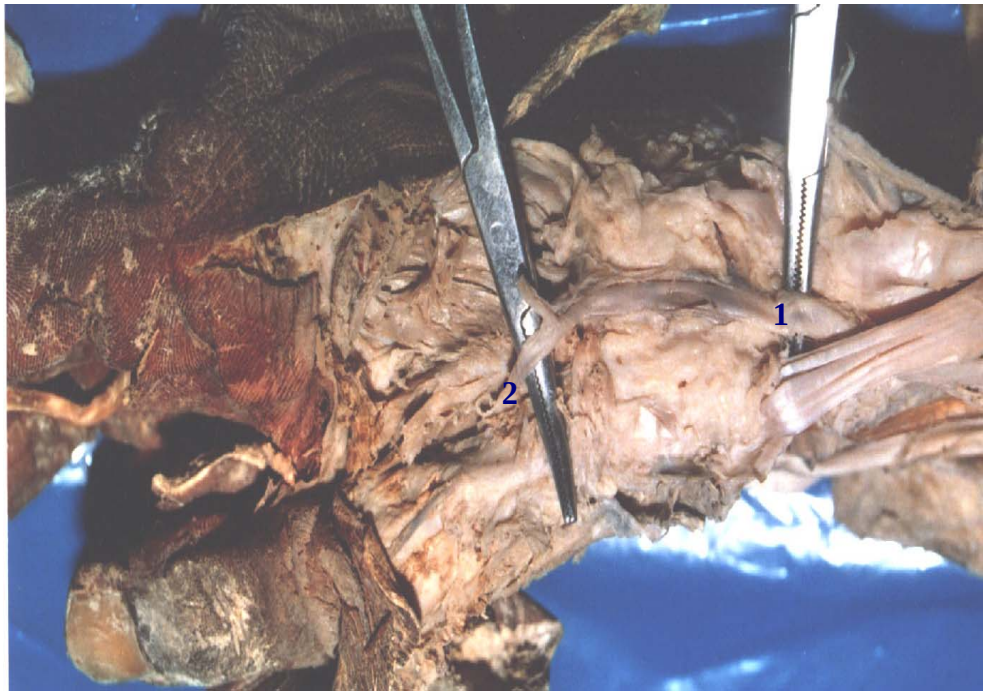



1. Brachial Artery 2. Radial Artery
3. Ulnar Artery

## FIG – 25 COURSE OF RADIAL ARTERY IN FOREARM

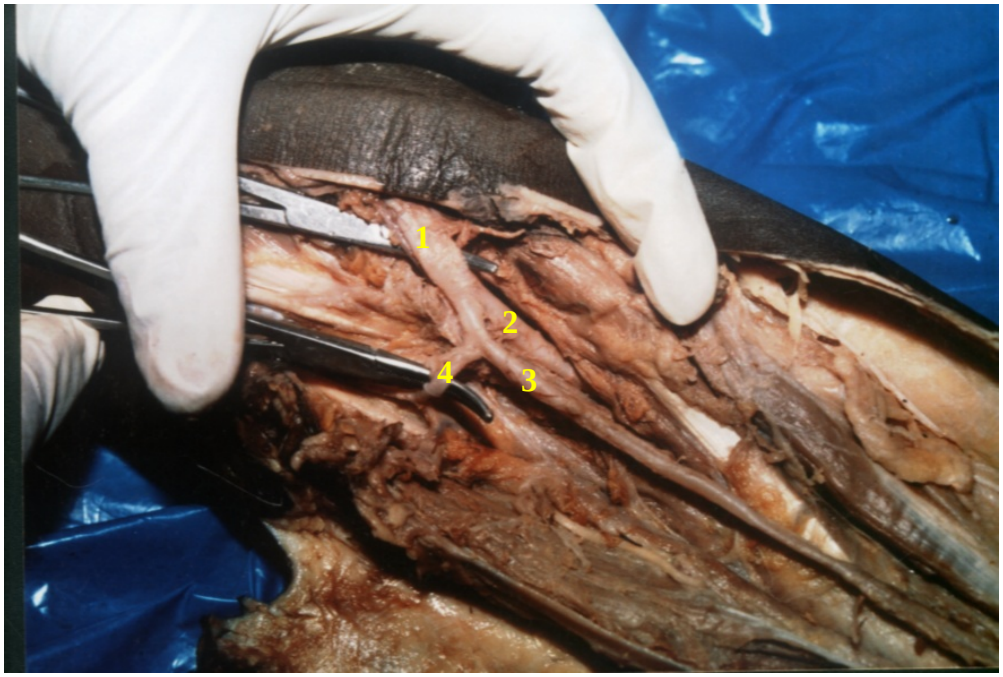

1. Brachial Artery
2. Radial Artery
3. Ulnar Artery
4. Biceps Tendon

## FIG – 26 COURSE OF RADIAL ARTERY – DORSUM OF HAND



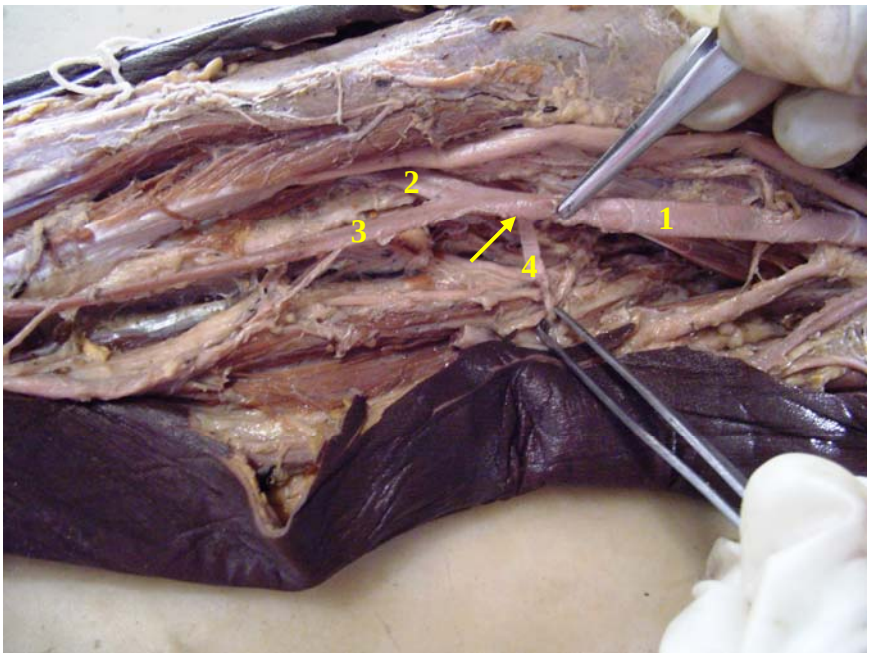

1. Radial Artery in the Anatomical Snuff Box
2. Radial Artery entering through 2 heads of dorsal interosseus muscle

**FIG – 27 ORIGIN OF RADIAL RECURRENT ARTERY**



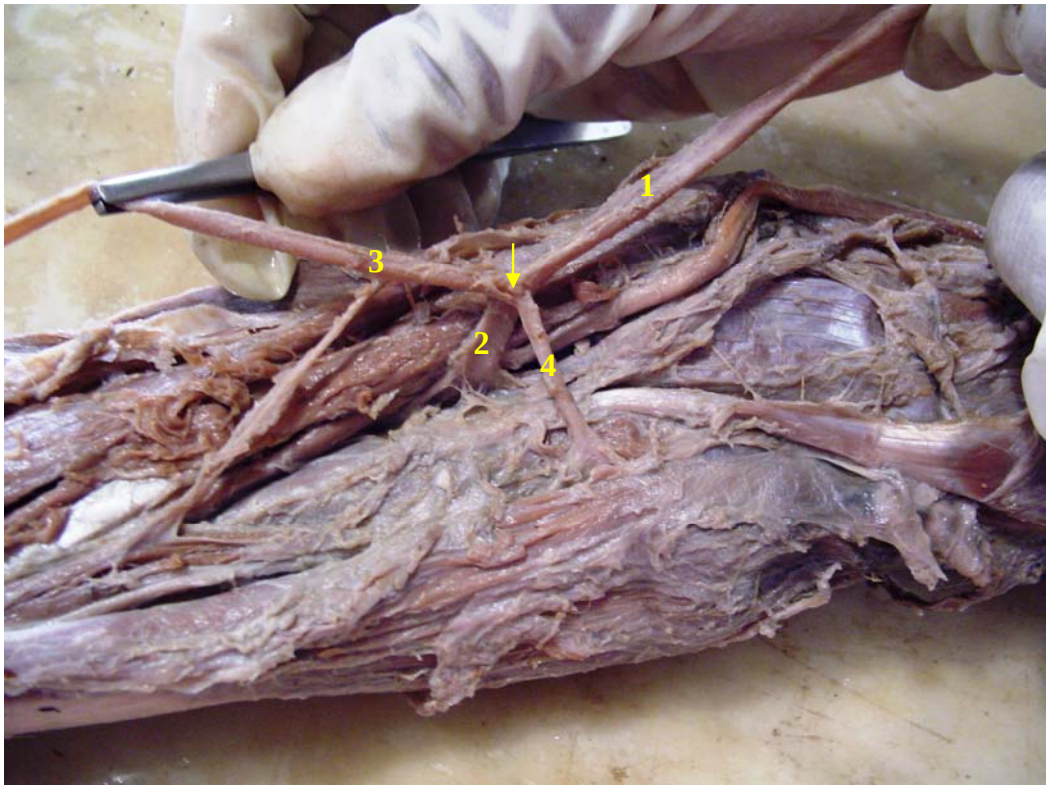

1. Brachial Artery
2. Ulnar Artery
3. Radial Artery
4. Radial Recurrent Artery

**FIG – 28 ORIGIN OF RADIAL RECURRENT ARTERY FROM BRACHIAL ARTERY**



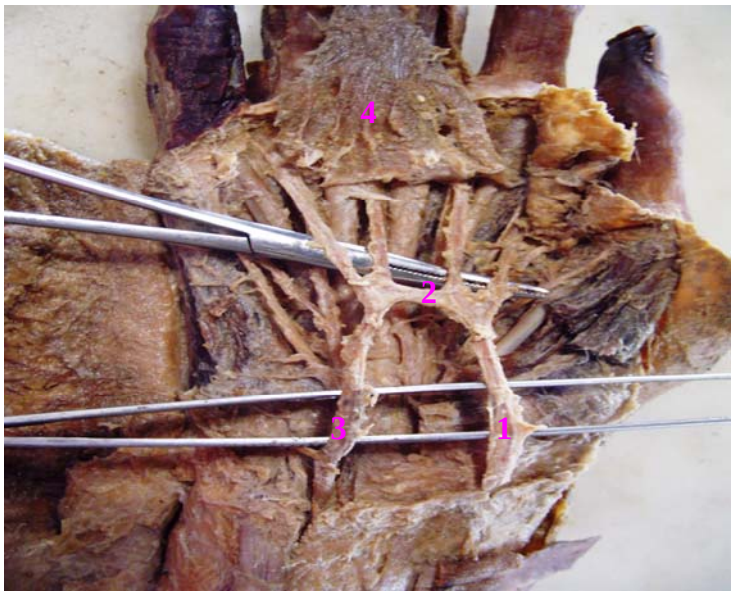

1. Brachial Artery
2. Ulnar Artery
3. Radial Artery
4. Radial Recurrent Artery

**FIG -29 ORIGIN OF RADIAL RECURRENT ARTERY – AT BIFURCATION LEVEL**



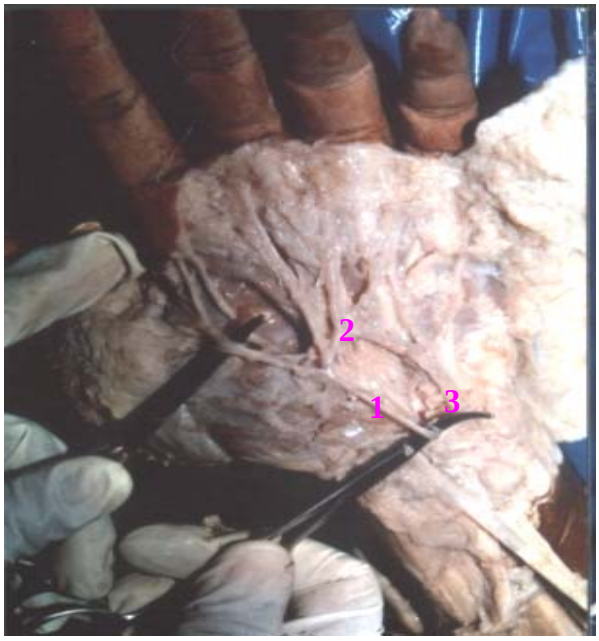

1. Brachial Artery
2. Ulnar Artery
3. Radial Artery
4. Radial Recurrent Artery

**FIG-30 SUPERFICIAL PALMAR BRANCH COMPLETING SUPERFICIAL PALMAR ARCH**



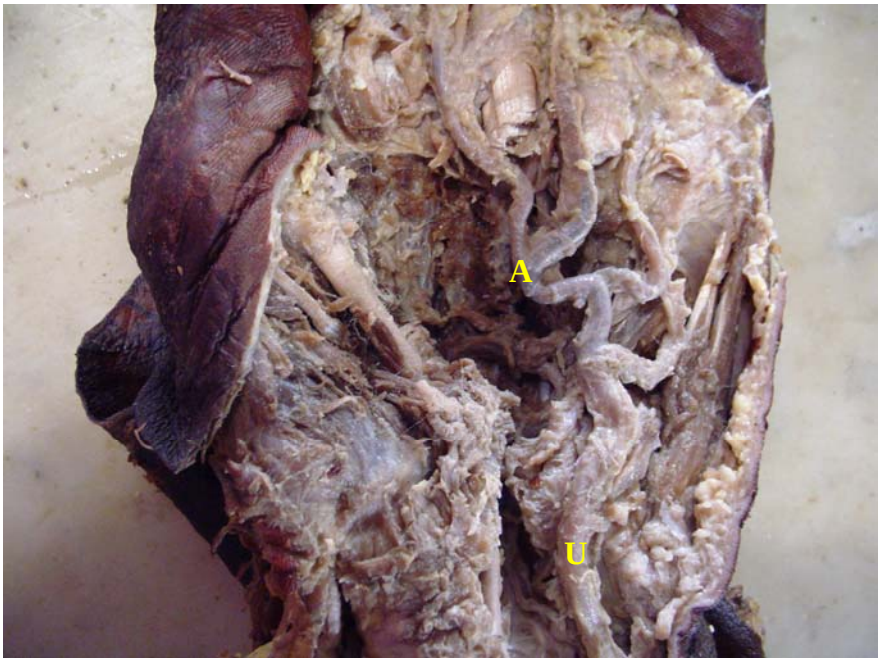

1. Superficial Palmar Branch
2. Superficial Palmar Arch
3. Ulnar Artery
4. Palmar Aponeurosis –Reflected

**FIG-31 SUPERFICIAL PALMAR ARCH COMPLETED BY SUPERFICIAL PALMAR BRANCH**



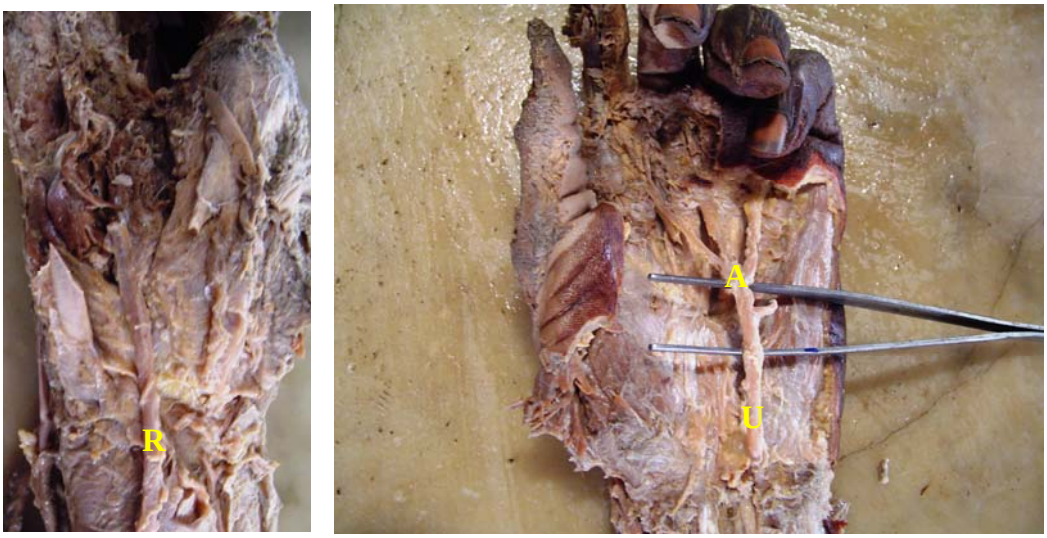

1. Superficial Palmar Branch 2. Superficial Palmar Arch
3. Ulnar Artery

**FIG-32 INCOMPLETE SUPERFICIAL PALMAR ARCH**



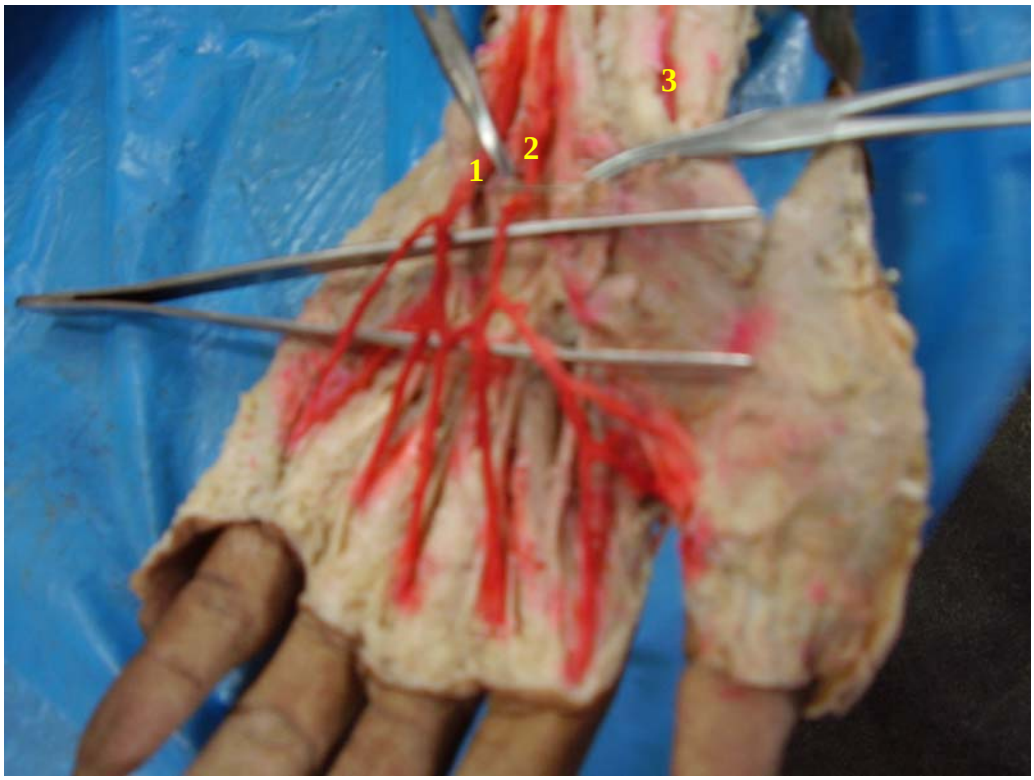

A – Incomplete Arch U – Ulnar Artery

**FIG –33 SUPERFICIAL PALMAR ARCH – INCOMPLETE**



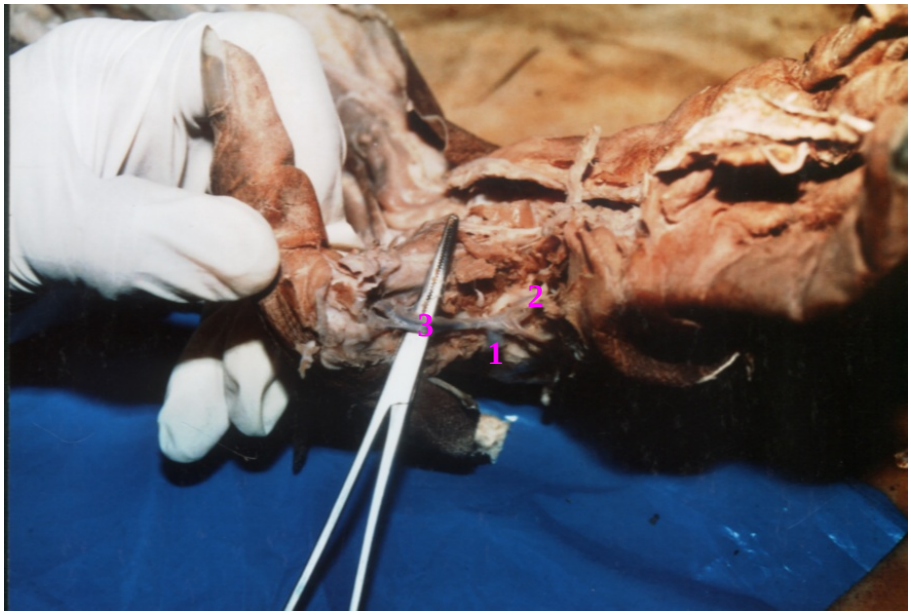

R – Radial Artery over the dorsum of hand
A - Incomplete Arch U – Ulnar Artery

**FIG – 34 SUPERFICIAL PALMAR ARCH – COMPLETED BY MEDIAN ARTERY**



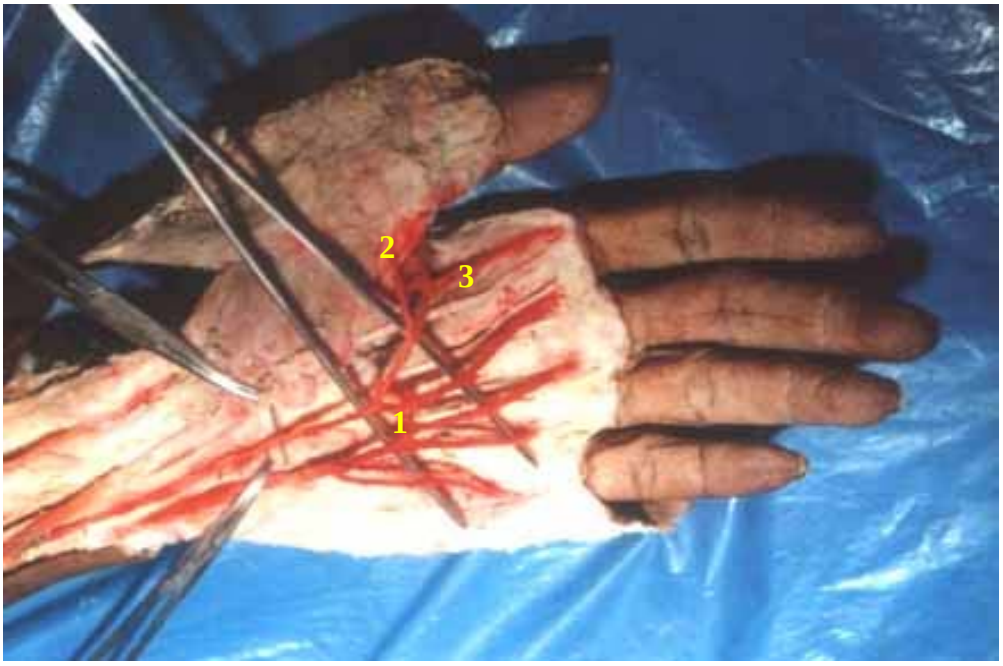

1. Ulnar Artery
2. Median Artery
3. Radial Artery

**FIG – 35 ARTERIA PRINCEPS POLLICIS, ARTERIA RADIALIS INDICIS ARISING FROM RADIAL ARTERY – PALMAR SIDE**




1. Radial Artery 2. Arteria Radialis Indicis
3. Arteria Princeps Pollicis

**FIG – 36 ARTERIA PRINCEPS POLLICIS, ARTERIA RADIALIS INDICIS ARISING FROM SUPERFICIAL PALMAR ARCH**

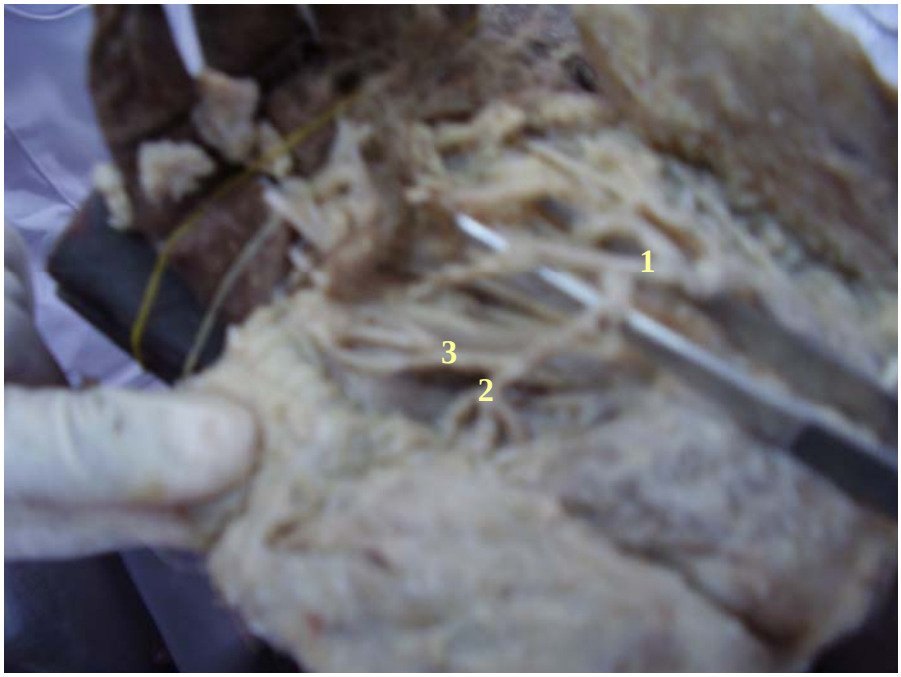



1. Superficial Palmar Arch 2. Arteria Princeps Pollicis
3. Arteria Radialis Indicis

**FIG – 37 ARTERIA PRINCEPS POLLICIS, ARISING FROM RADIAL ARTERY – DORSAL SIDE**


RA – Radial Artery APP – Arteria Princeps Pollicis

**FIG – 38 ARTERIA PRINCEPS POLLICIS, ARTERIA RADIALIS INDICIS ARISING FROM SUPERFICIAL PALMAR BRANCH OF RADIAL ARTERY**

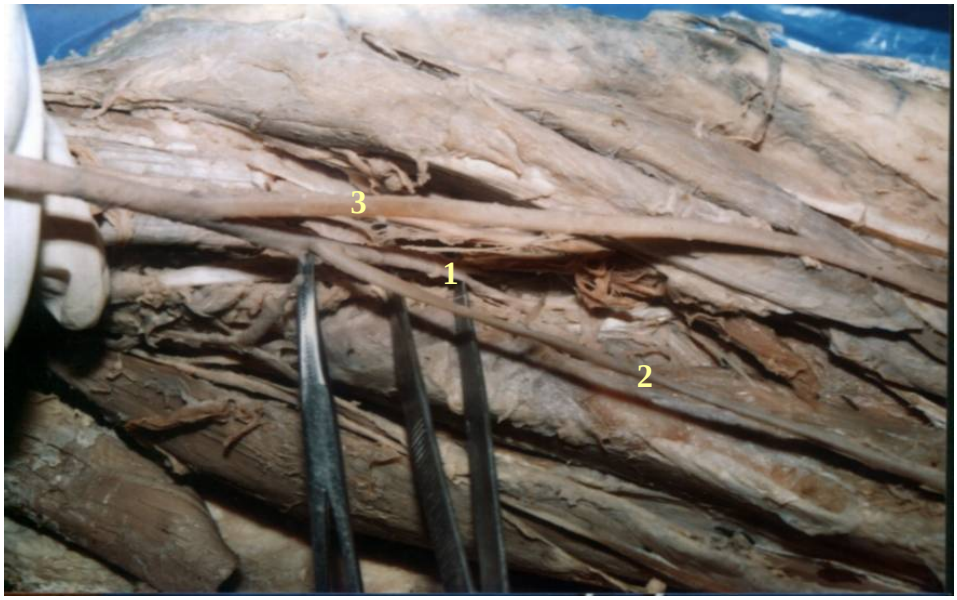



1. Superficial Palmar Branch 2. Arteria Princeps Pollicis
3. Arteria Radialis Indicis

**FIG – 39 PALMAR AND DORSAL CARPAL BRANCHES**

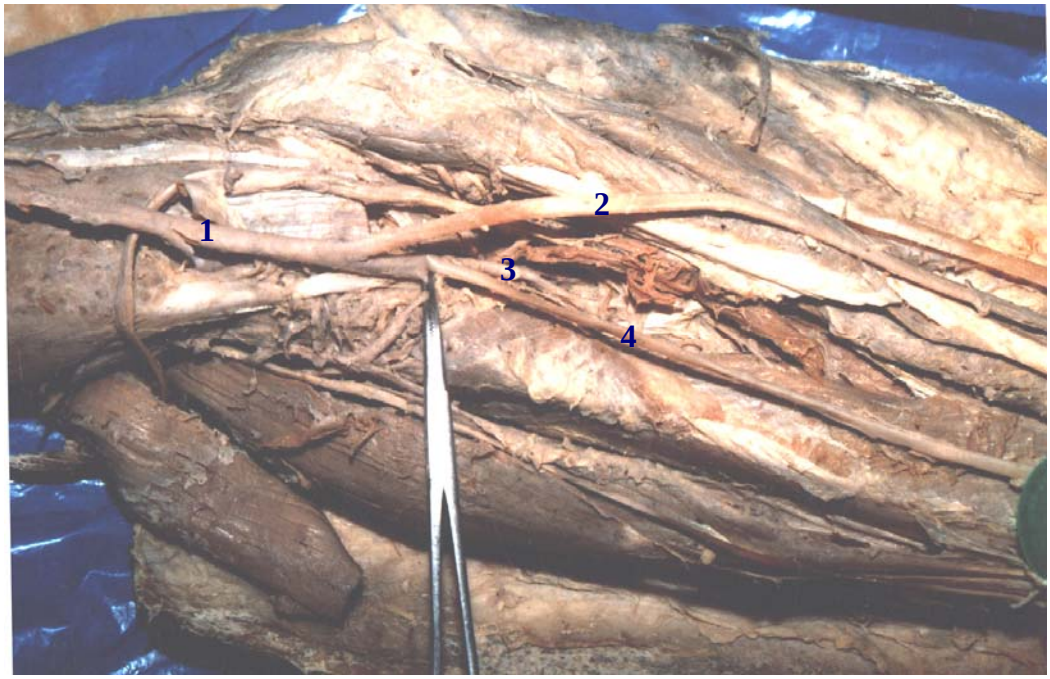

1. Palmar Carpal Branch 2. Dorsal Carpal Branch

**FIG – 40 ORIGIN OF COMMON INTEROSSEOUS ARTERY FROM RADIAL ARTERY**




1. Common interosseous artery 2. Radial artery 3. Ulnar artery

**FIG – 41 ORIGIN OF COMMON INTEROSSEOUS ARTERY FROM RADIAL ARTERY**

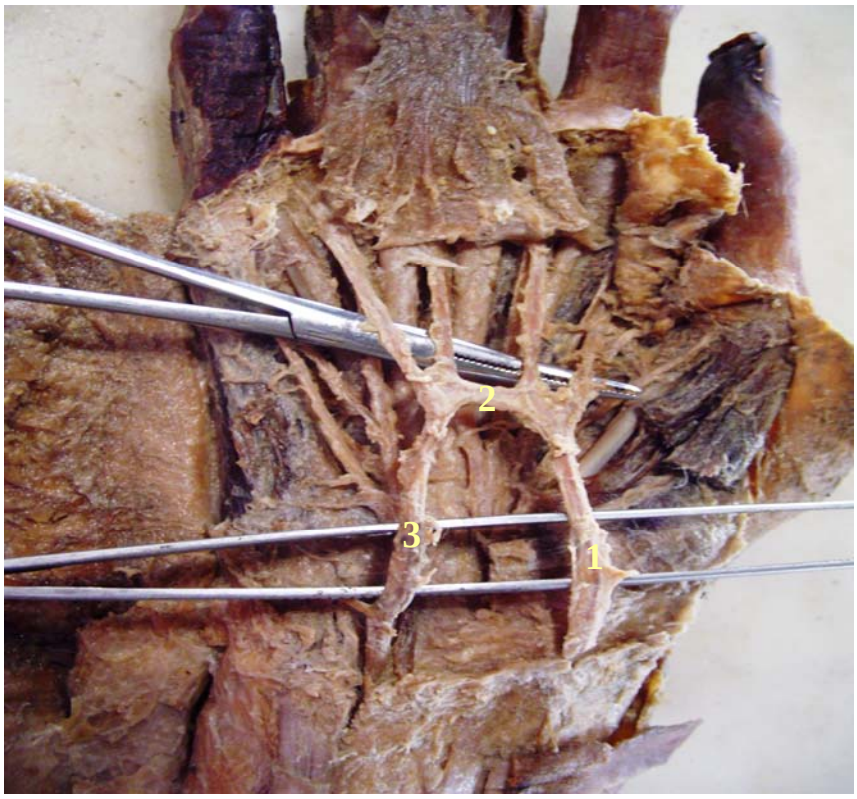



1. Brachial Artery
2. Ulnar Artery
3. Common Interosseous Artery
4. Radial Artery

**FIG – 42 ORIGIN OF ANTERIOR INTEROSSEOUS ARTERY FROM RADIAL ARTERY**


1. Radial Artery
2. Ulnar Artery
3. Posterior Interosseous Artery
4. Anterior interosseous artery

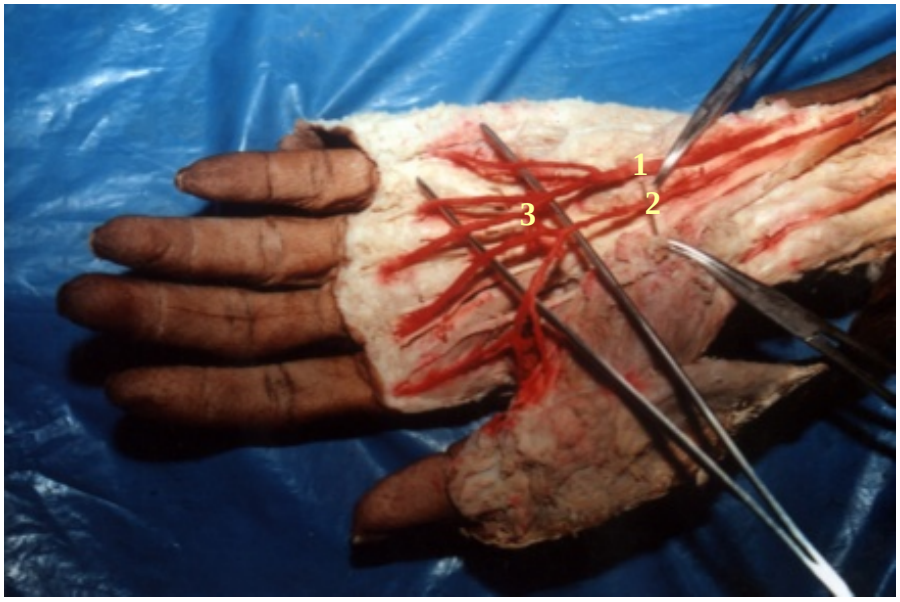
**FIG 43 SUPERFICIAL PALMAR ARCH COMPLETED BY SUPERFICIAL PALMAR BRANCH**




1. Superficial Palmar Branch 2. Superficial Palmar Arch
3. Ulnar Artery

**FIG 44 MUSCULAR BRANCHES FROM RADIAL ARTERY**

**FIG 45 SUPERFICIAL PALMAR ARCH COMPLETED BY MEDIAN ARTERY**




1. Ulnar Artery 2. Median Artery 3. Superficial Palmar Arch

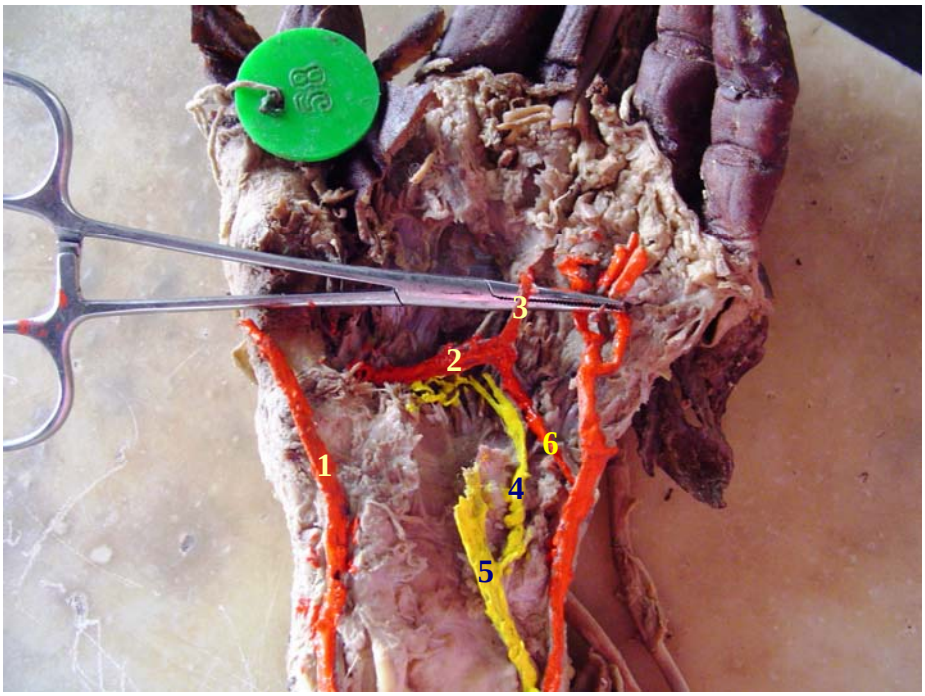
**FIG 46 SUPERFICIAL PALMAR ARCH – INCOMPLETE**


1. Incomplete Arch 2. Ulnar Artery

## FIG 47 (A) DEEP PALMAR ARCH

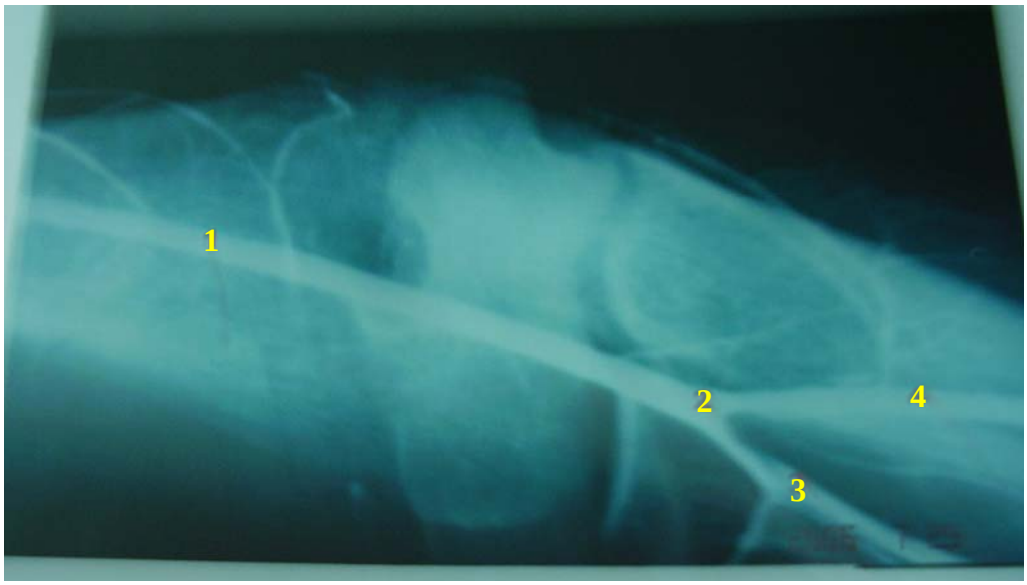

1. Deep Palmar Arch 2. Deep Branch of Ulnar nerve
3. Superficial Palmar Arch – Cut End 4. Superficial Palmar Branch

## FIG 47 (B) DEEP PALMAR ARCH




1. Superficial Palmar Branch 2. Deep Palmar Arch
3.Metacarpal Artery 4. Deep Branch of Ulnar nerve
5. Ulnar nerve 6. Deep Branch of Ulnar Artery

**FIG – 48 CADAVERIC ANGIOGRAM STUDY - ORIGIN OF RADIAL ARTERY**

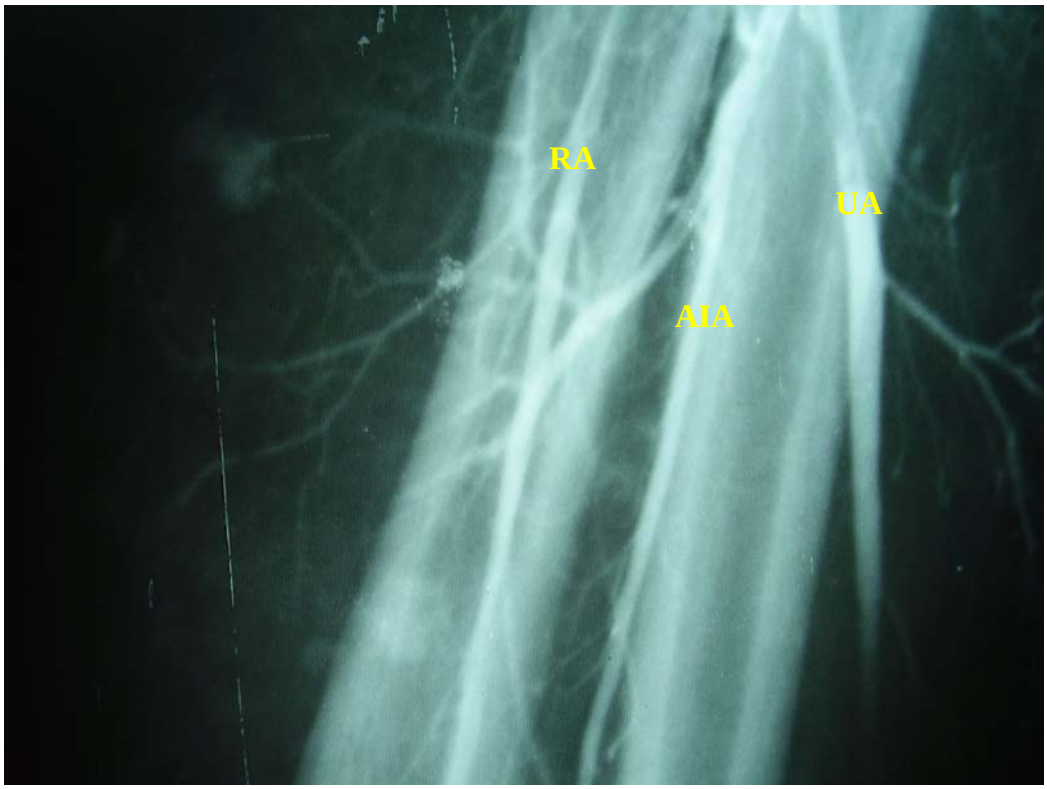



1. Brachial Artery
2. Point of bifurcation
3. Radial artery
4. Ulnar artery

**FIG – 49 CADAVERIC ANGIOGRAM STUDY**


1. Brachial Artery
2. Ulnar artery
3. Radial artery

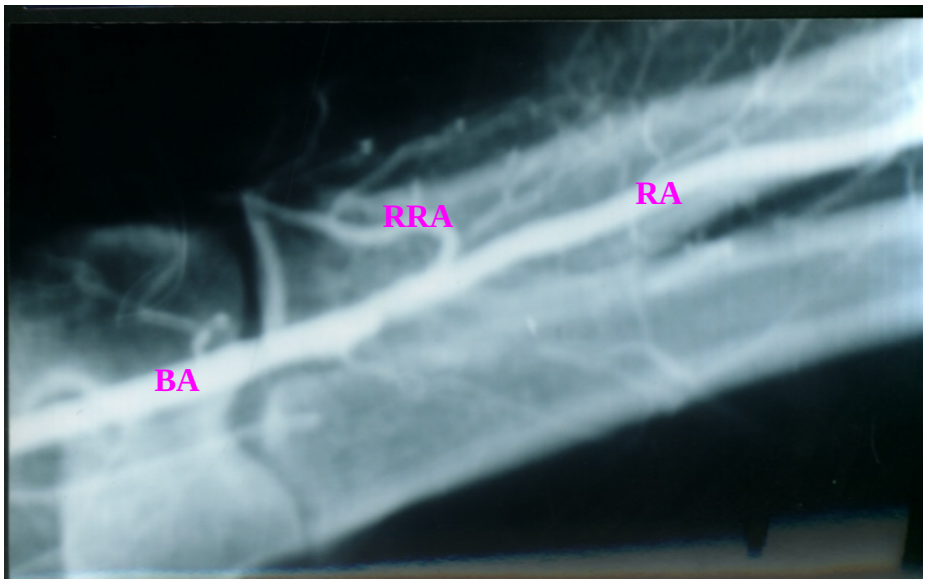
**FIG – 50 CADAVERIC ANGIOGRAM STUDY – COURSE OF RADIAL ARTERY**




RA - Radial Artery  UA - Ulnar Artery  AIA - Anterior interosseous artery

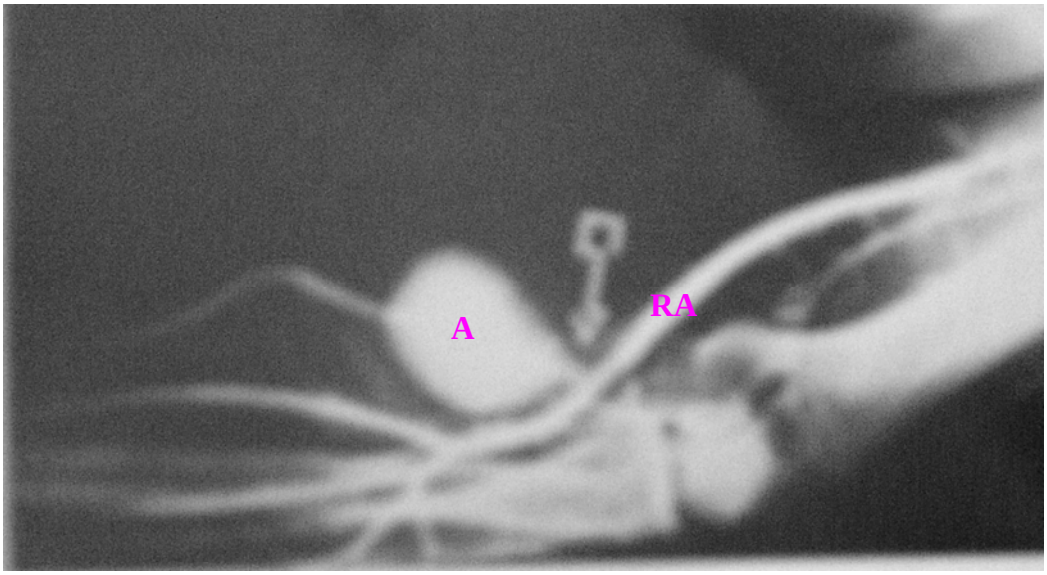
**FIG – 51 CADAVERIC ANGIOGRAM STUDY – DEEP PALMAR ARCH**

**FIG – 52 CLINICAL STUDY BY ANGIOGRAPHY METHOD**
**ULNAR ARTERY OCCLUSION**




BA – Brachial Artery RA – Radial Artery
RRA – Radial Recurrent Artery

**FIG – 53 CLINICAL STUDY BY ANGIOGRAPHY METHOD**
**PSEUDOANEURYSM OF RADIAL RECURRENT ARTERY**




A – Pseudoaneurysm RA – Radial Artery

**FIG – 54 DOPPLER STUDY OF RADIAL ARTERY**

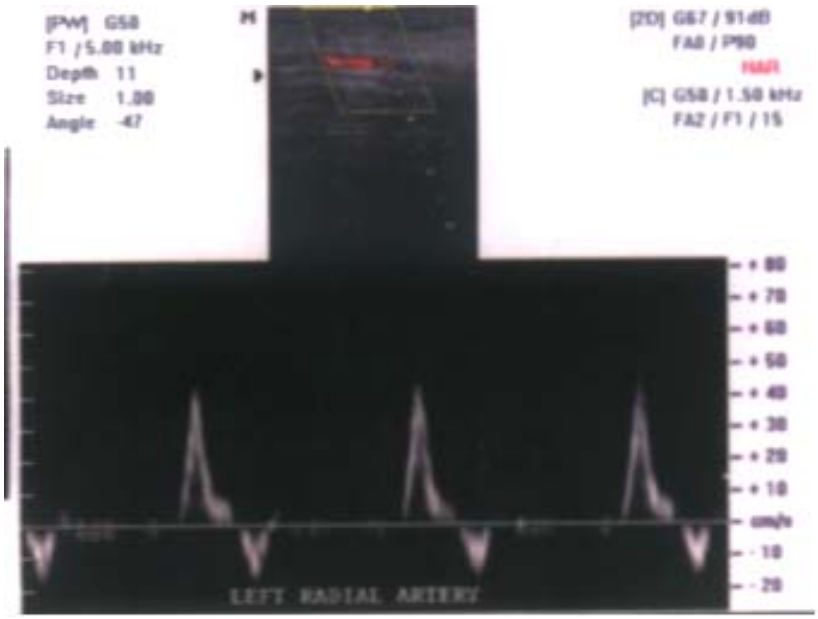



**FIG – 55 DOPPLER STUDY OF RADIAL ARTERY**

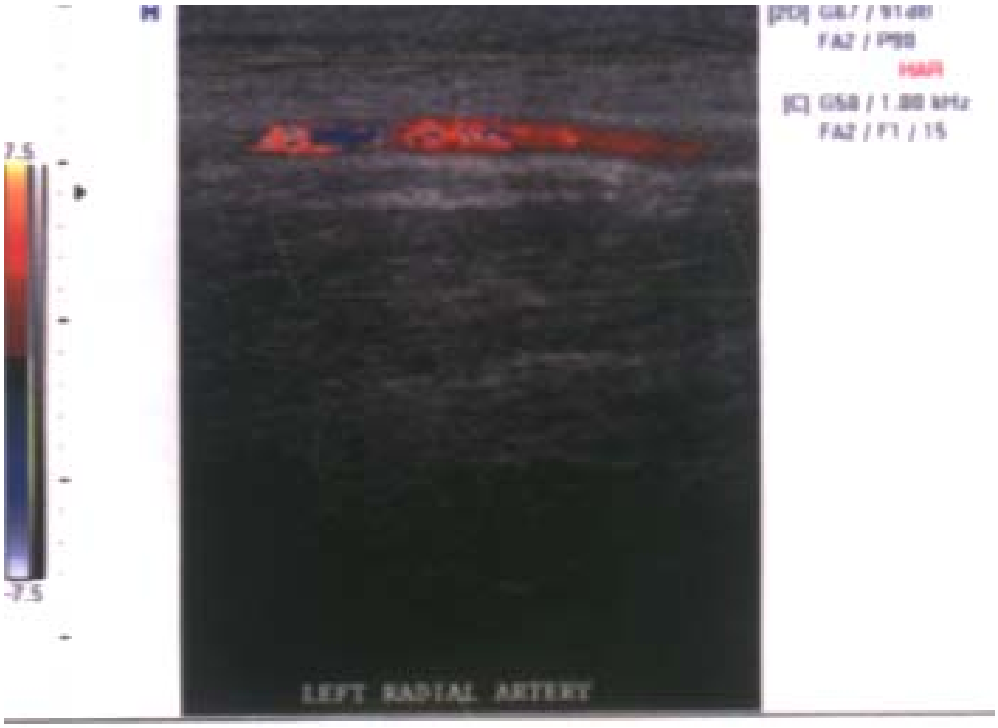


**FIG – 56 MICROSTRCUTURE OF RADIAL ARTERY**

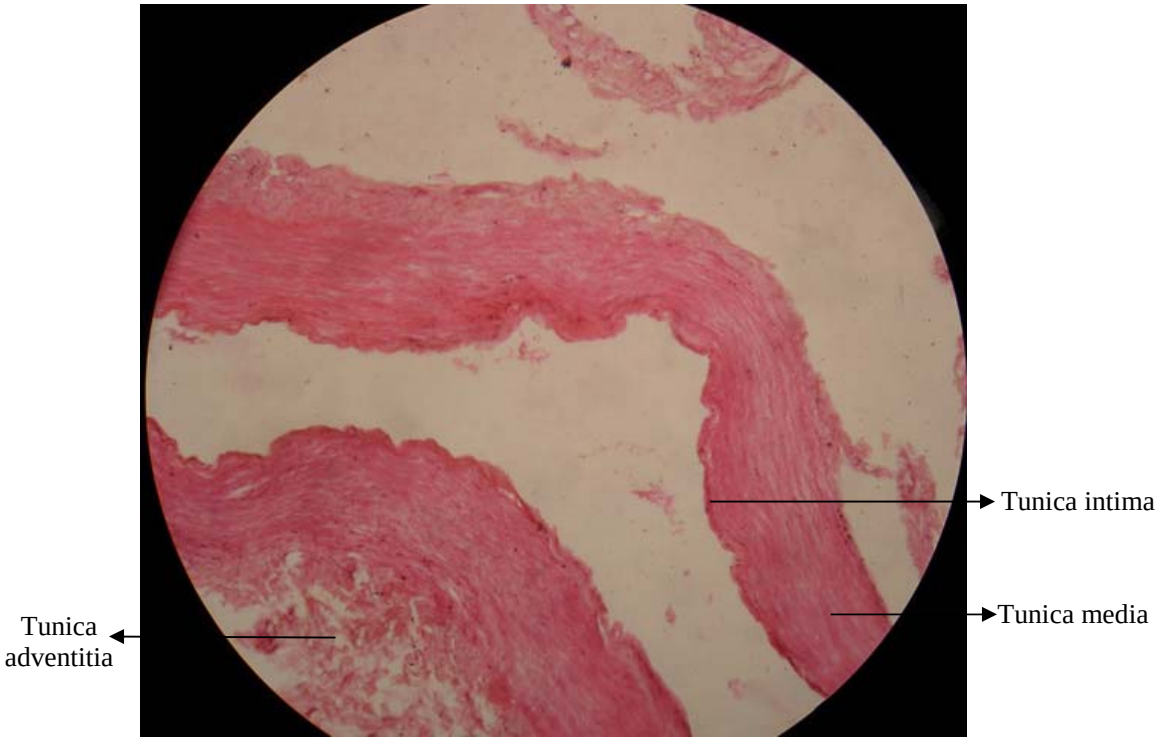



**FIG – 57 MICROSTRCUTURE OF CORONARY ARTERY**

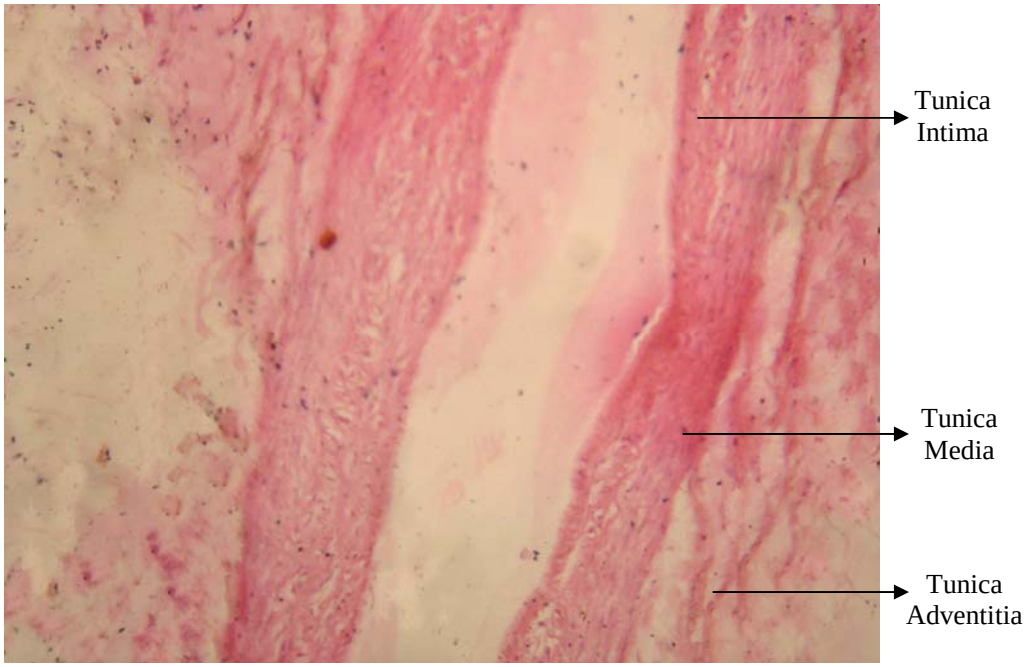


**FIG – 58 MICROSTRUCTURE OF RADIAL ARTERY**

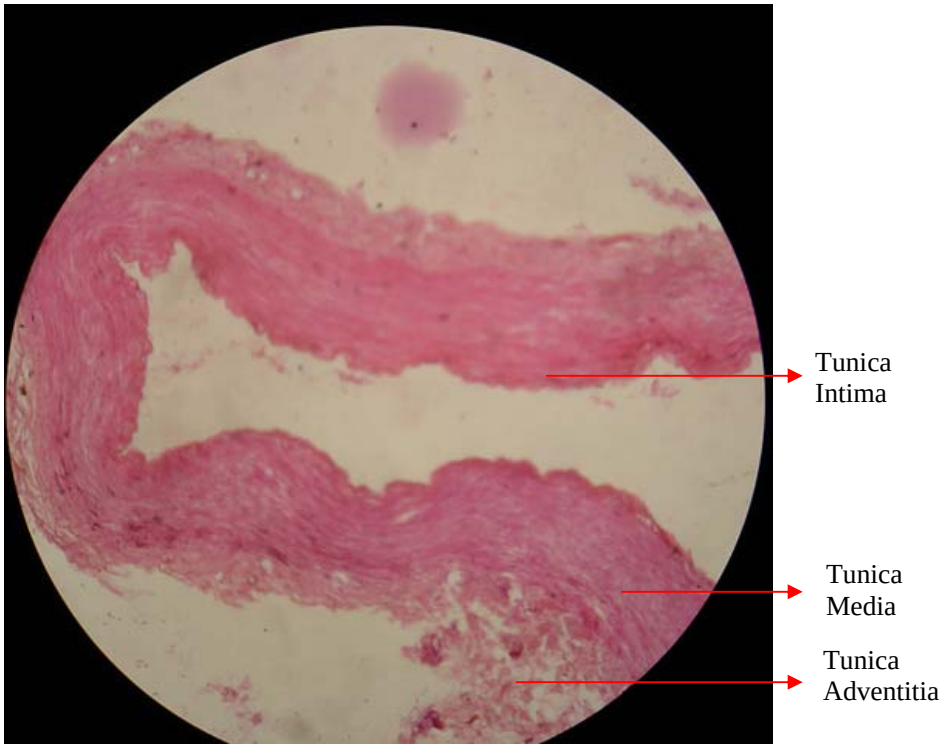



**FIG – 59 MICROSTRUCTURE OF CORONARY ARTERY**

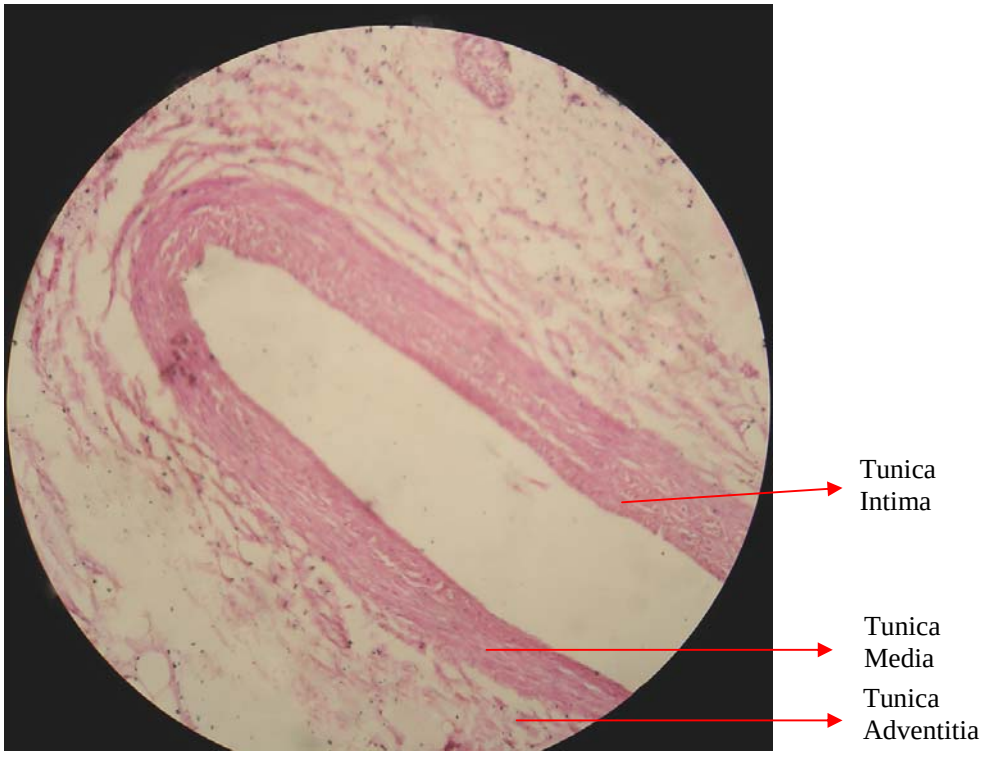


**FIG – 60 COMPLICATION FOLLOWING INTRAARTERIAL INJECTION – GANGRENE OF FINGERS**

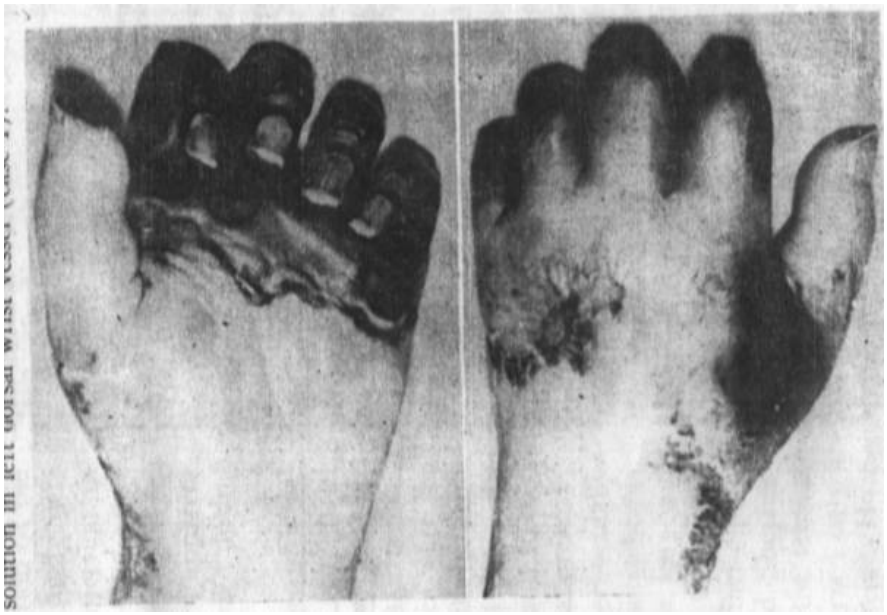
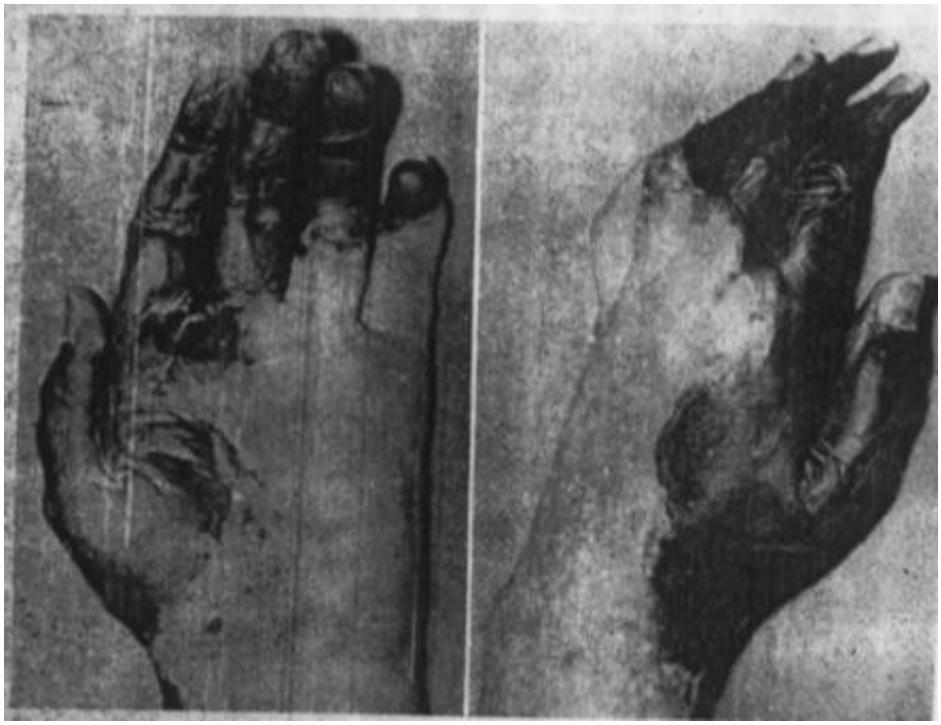


**FIG – 61 GANGRENE OF THUMB & FINGERS FOLLOWING INTRAARTERIAL INJECTION**

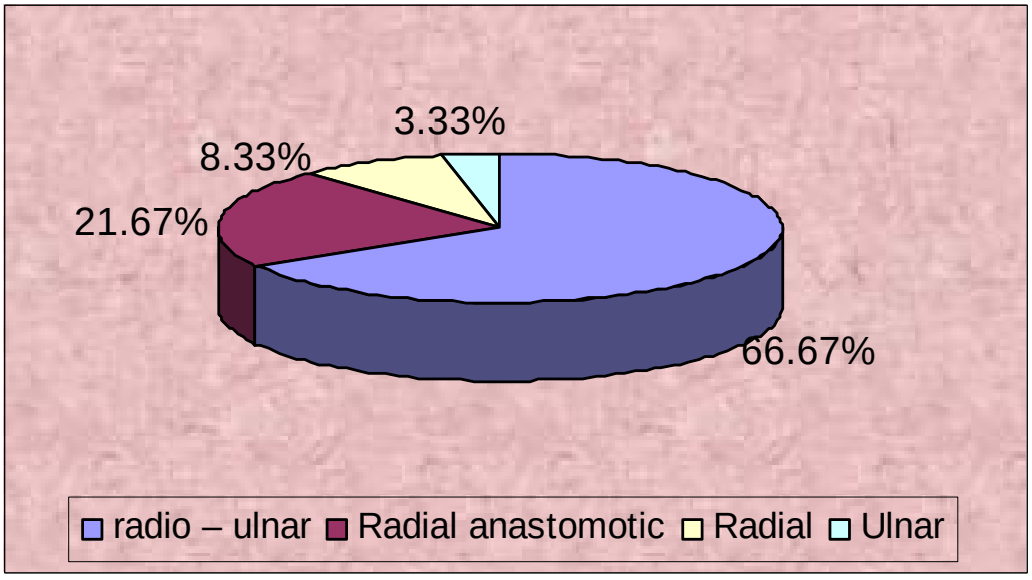


## TABLE – 1

## DEEP PALMAR ARCH – DESCRIPTION

## BY MEZZOGIORNO ET AL (1994)

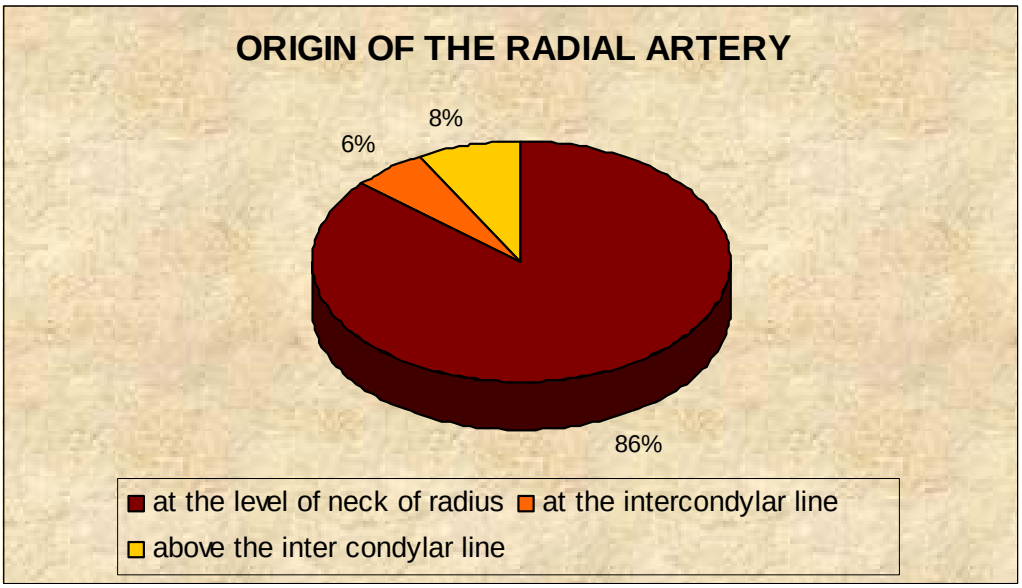
| | | **Percentage** |
|---|---|---|
| 1 | Radio – ulnar | 66.67% |
| 2 | Radial anastomotic | 21.67% |
| 3 | Radial | 8.33% |
| 4 | Ulnar | 3.33% |



## TABLE – 2

## ORIGIN OF THE RADIAL ARTERY

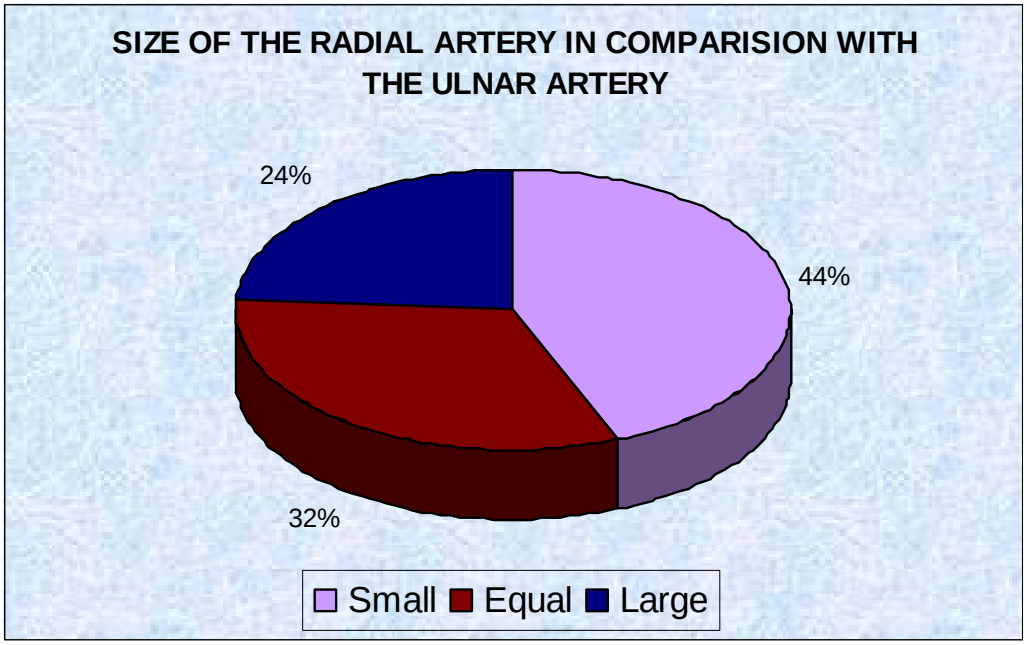
| Sl.No. | Level of origin | No.of specimens | Percentage |
|---|---|---|---|
| 1 | at the level of neck of radius | 43 | 86% |
| 2 | at the intercondylar line | 3 | 6% |
| 3 | above the inter condylar line | 4 | 8% |



## TABLE – 3

## SIZE OF THE RADIAL ARTERY IN COMPARISION WITH THE ULNAR ARTERY

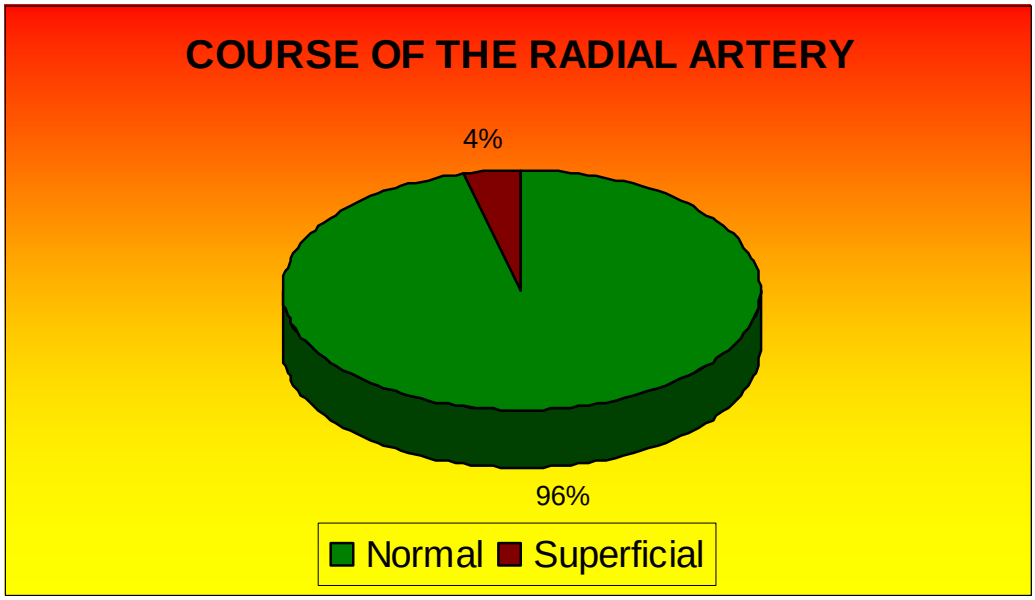
| Sl.No. | Size of the radial artery | No.of specimens | Percentage |
|---|---|---|---|
| 1 | Small | 22 | 44% |
| 2 | Equal | 16 | 32% |
| 3 | Large | 12 | 24% |



## TABLE – 4

## COURSE OF THE RADIAL ARTERY

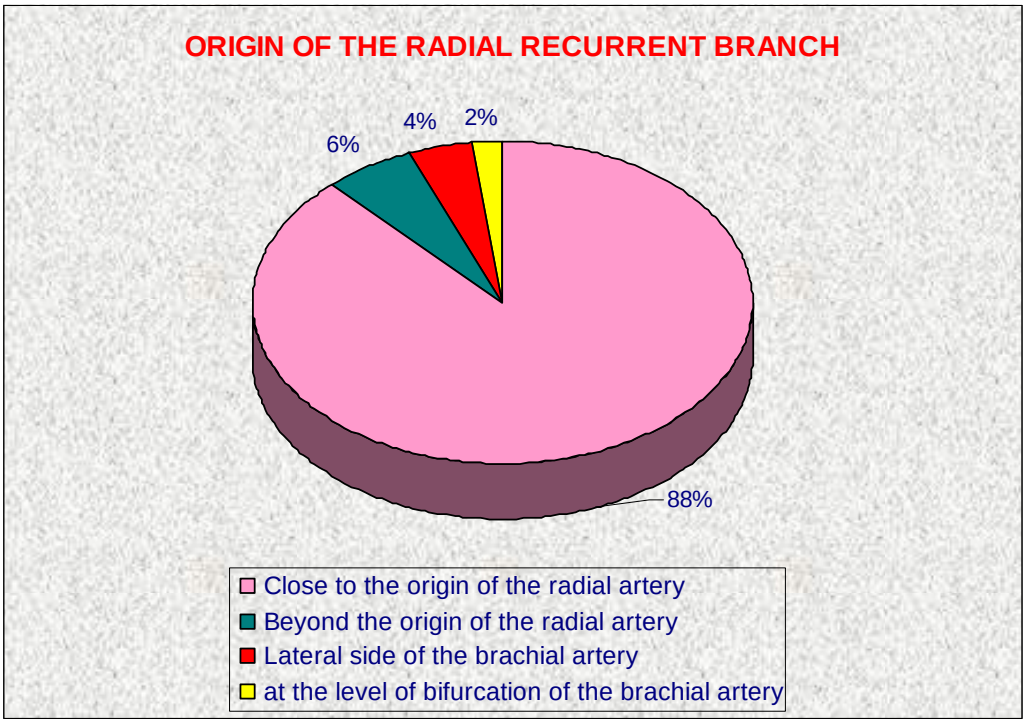
| Sl.No. | Description | No.of specimens | Percentage |
|---|---|---|---|
| 1 | Normal | 48 | 96% |
| 2 | Superficial | 2 | 4% |



## TABLE – 5

## ORIGIN OF THE RADIAL RECURRENT BRANCH

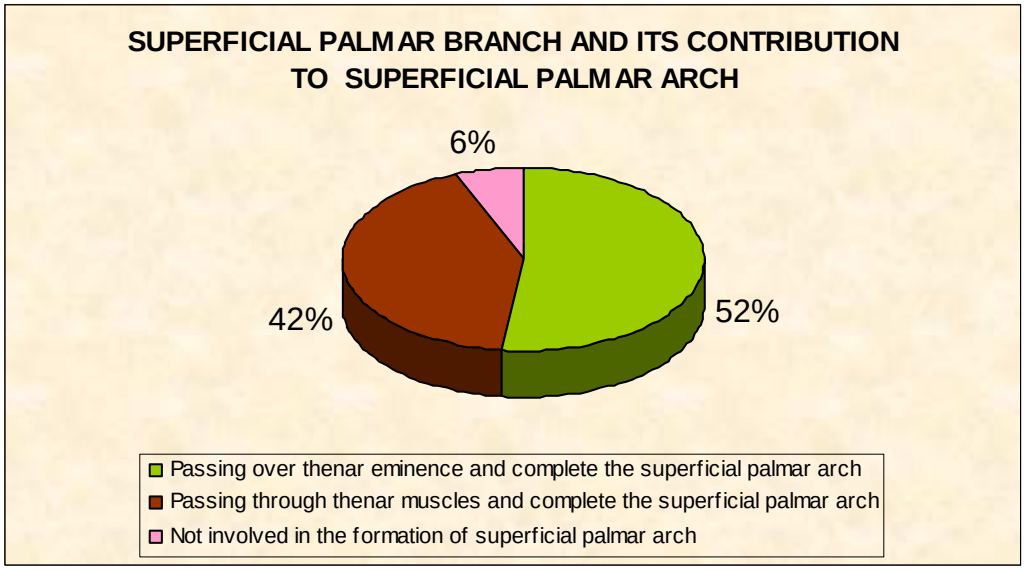
| Sl. No. | Description | No.of specimens | Percentage |
|---|---|---|---|
| 1 | Close to the origin of the radial artery | 44 | 88% |
| 2 | Beyond the origin of the radial artery | 3 | 6% |
| 3 | Lateral side of the brachial artery | 2 | 4% |
| 4 | at the level of bifurcation of the brachial artery | 1 | 2% |



## TABLE – 6

## SUPERFICIAL PALMAR BRANCH AND ITS CONTRIBUTION TO SUPERFICIAL PALMAR ARCH

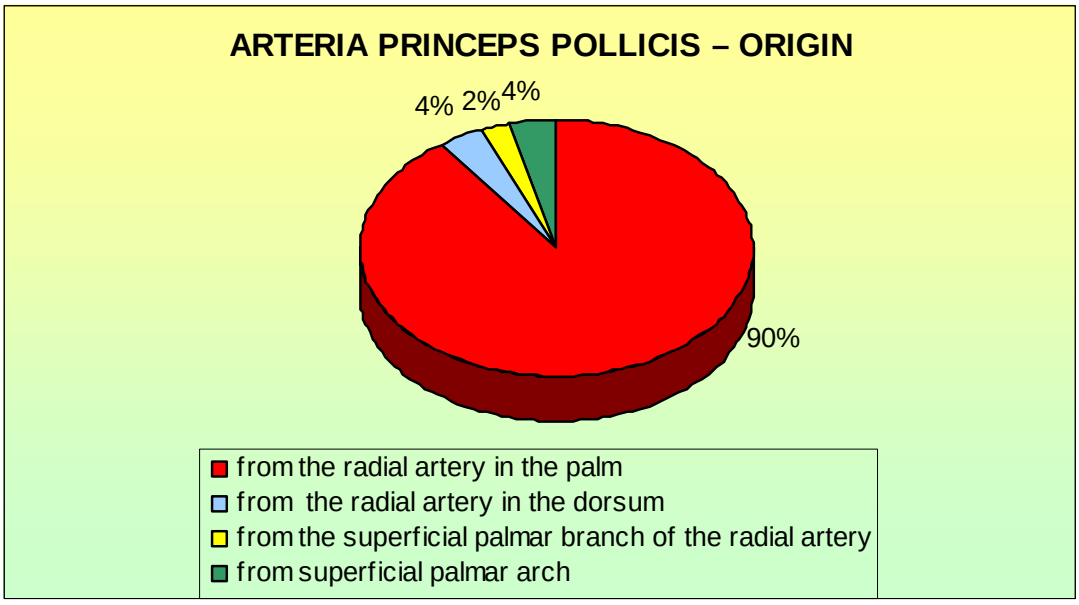
| Sl.No. | Description | No. of specimens | Percentage |
|---|---|---|---|
| 1 | Passing over thenar eminence and complete the superficial palmar arch | 26 | 52% |
| 2 | Passing through thenar muscles and complete the superficial palmar arch | 21 | 42% |
| 3 | Not involved in the formation of superficial palmar arch | 3 | 6% |



## TABLE – 7

## ARTERIA PRINCEPS POLLICIS – ORIGIN

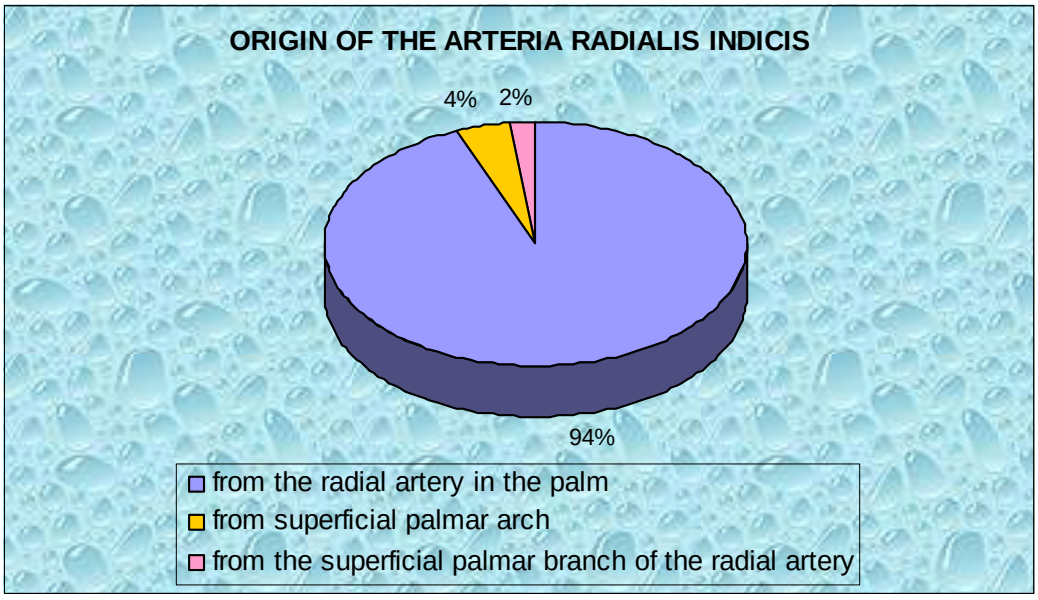
| Sl. No. | Description | No.of specimens | Percentage |
|---|---|---|---|
| 1 | from the radial artery in the palm | 45 | 90% |
| 2 | from the radial artery in the dorsum | 2 | 4% |
| 3 | from the superficial palmar branch of the radial artery | 1 | 2% |
| 4 | from superficial palmar arch | 2 | 4% |



## TABLE – 8

## ORIGIN OF THE ARTERIA RADIALIS INDICIS

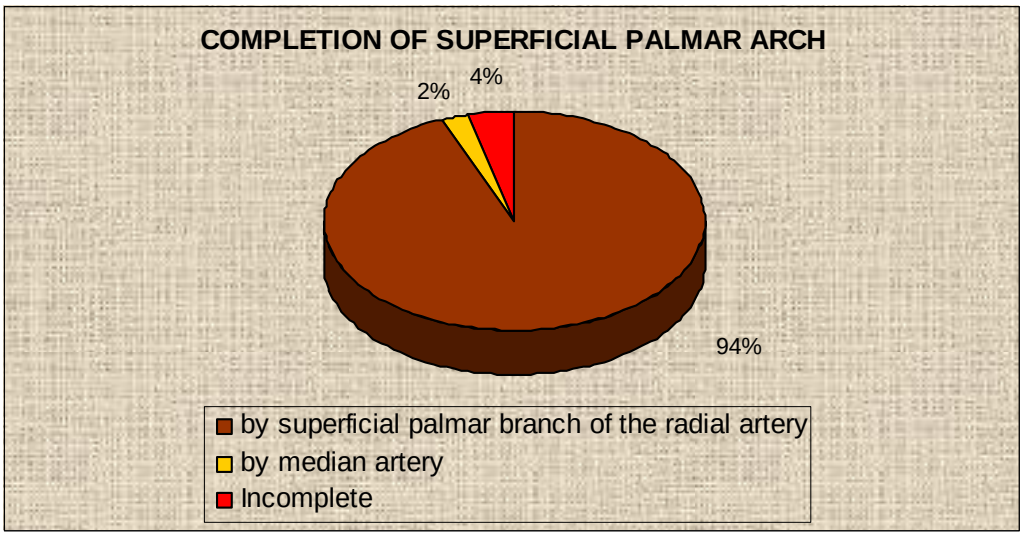
| Sl.No. | Description | No. of specimens | Percentage |
|---|---|---|---|
| 1 | from the radial artery in the palm | 47 | 94% |
| 2 | from superficial palmar arch | 2 | 4% |
| 3 | from the superficial palmar branch of the radial artery. | 1 | 2% |



# TABLE – 9

## COMPLETION OF SUPERFICIAL PALMAR ARCH

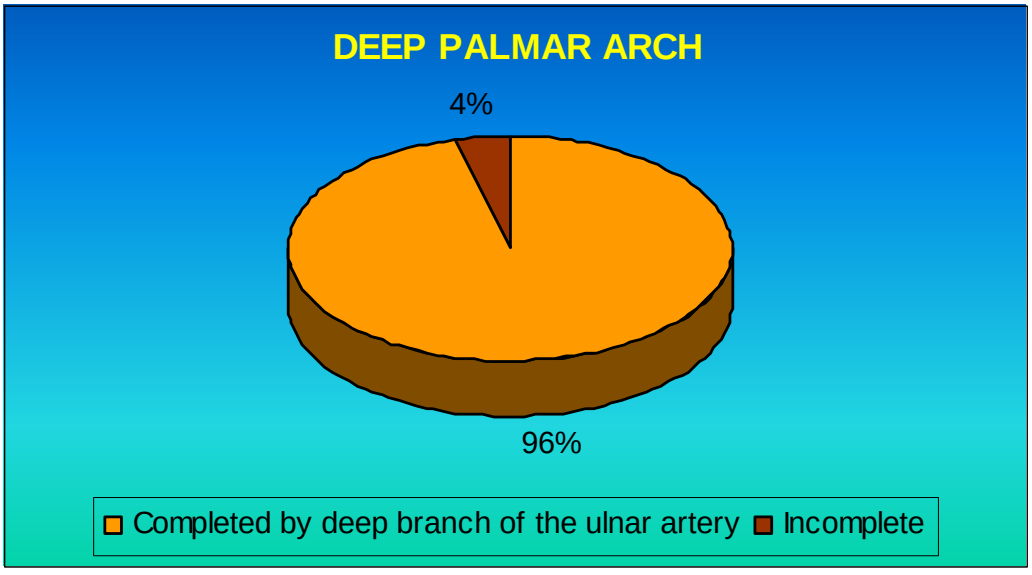
| Sl.No. | Description | No. of specimens | Percentage |
|---|---|---|---|
| 1 | by superficial palmar branch of the radial artery | 47 | 94% |
| 2 | by median artery | 1 | 2% |
| 3 | Incomplete | 2 | 4% |



## TABLE – 10

## DEEP PALMAR ARCH

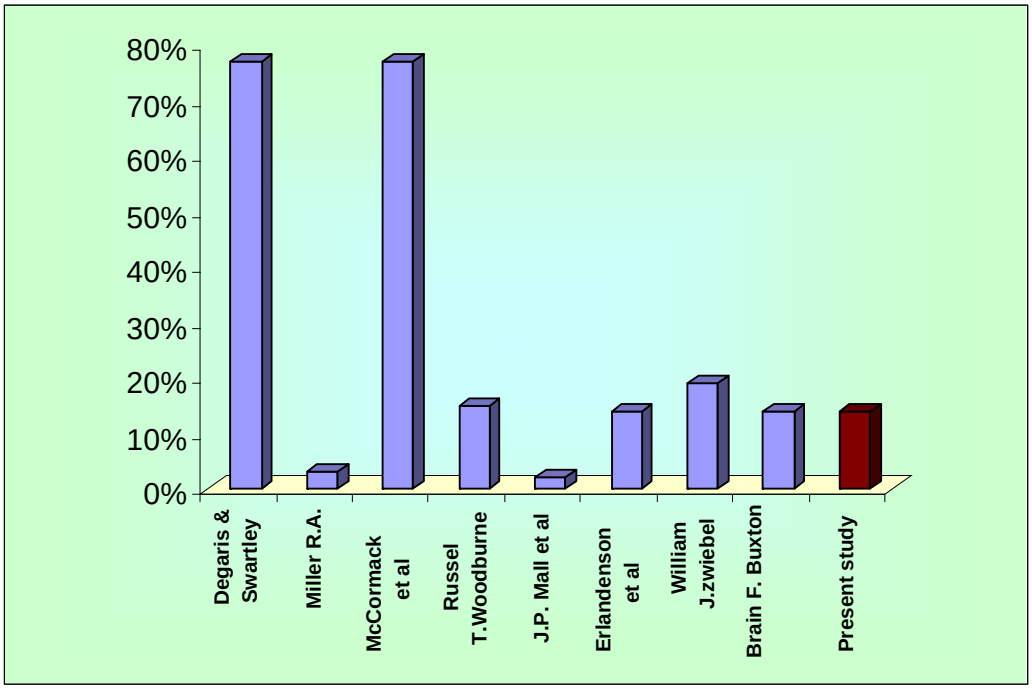
| Sl.No. | Description | No.of specimens | Percentage |
|---|---|---|---|
| 1 | Completed by deep branch of the ulnar artery | 48 | 96% |
| 2 | Incomplete | 2 | 4% |



## TABLE - 11

## HIGH ORIGIN OF THE RADIAL ARTERY

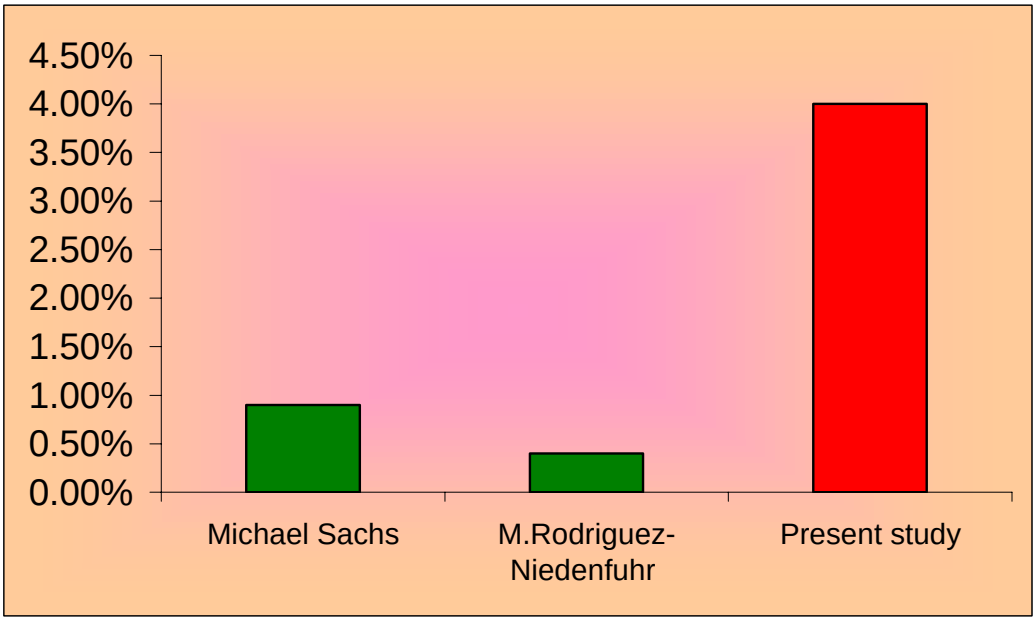
| | Percentage |
|---|---|
| Degaris and Swartley (1928) | 77% |
| Miller R.A. (1939) | 3% |
| McCormack et al (1953) | 77% |
| Russel T.Woodburne (1957) | 15% |
| J.P. Mall et al (1976) | 2.1% |
| Erlandson et al (1981) | 14% |
| William J.Zwiebel (1995) | 19% |
| Brain F. Buxton (1998) | 14% |
| Present study | 14% |



## TABLE – 12

## SUPERFICIAL COURSE OF RADIAL ARTERY

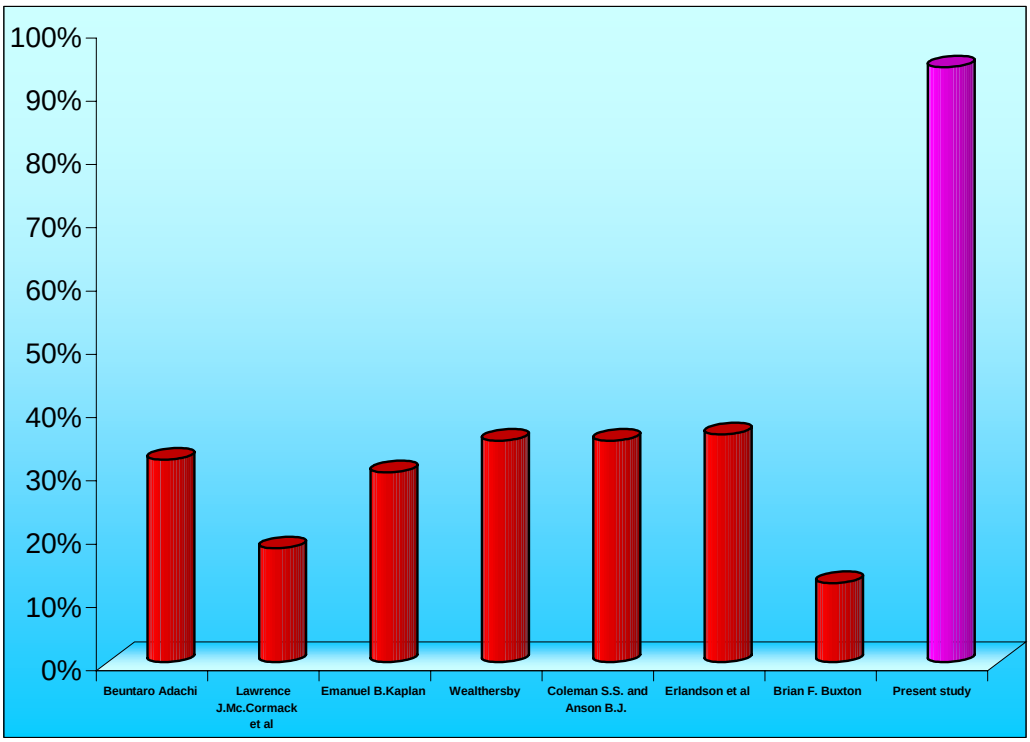
| | **Percentage** |
|---|---|
| Michael Sachs (1987) | 5 out of 570<br>0.9% |
| M.Rodriguez-Niedenfuhr (2003) | 0.4% |
| Present study | 4% |



## TABLE - 13

## COMPLETION OF SUPERFICIAL PALMAR ARCH BY THE SUPERFICIAL PALMAR BRANCH OF THE RADIAL ARTERY

| | Percentage |
|---|---|
| Beuntaro Adachi (1928) | 32% |
| Lawrence J.Mc Cormack et al (1953) | 18% |
| Emanuel B.Kaplan (1953) | 30% |
| Weathersby (1954) | 35% |
| Coleman S.S. and Anson B.J. (1961) | 35% |
| Erlandson et al (1981) | 36% |
| Brian F. Buxton (1998) | 12.5% |
| Present study | 94% |



## TABLE – 14

## FORMATION OF DEEP PALMAR ARCH BY THE TERMINAL BRANCH OF THE RADIAL AND DEEP PALMAR BRANCH OF THE ULNAR ARTERY

| | **Percentage** |
|---|---|
| Brian F. Buxton (1998) | 87.5% |
| Mezzogiorno (1994) | 66.67% |
| Rohart B.Rutherford (2005) | 97% |
| Present study | 96% |